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FOR RESEARCH & DEVELOPMENT MANAGERS

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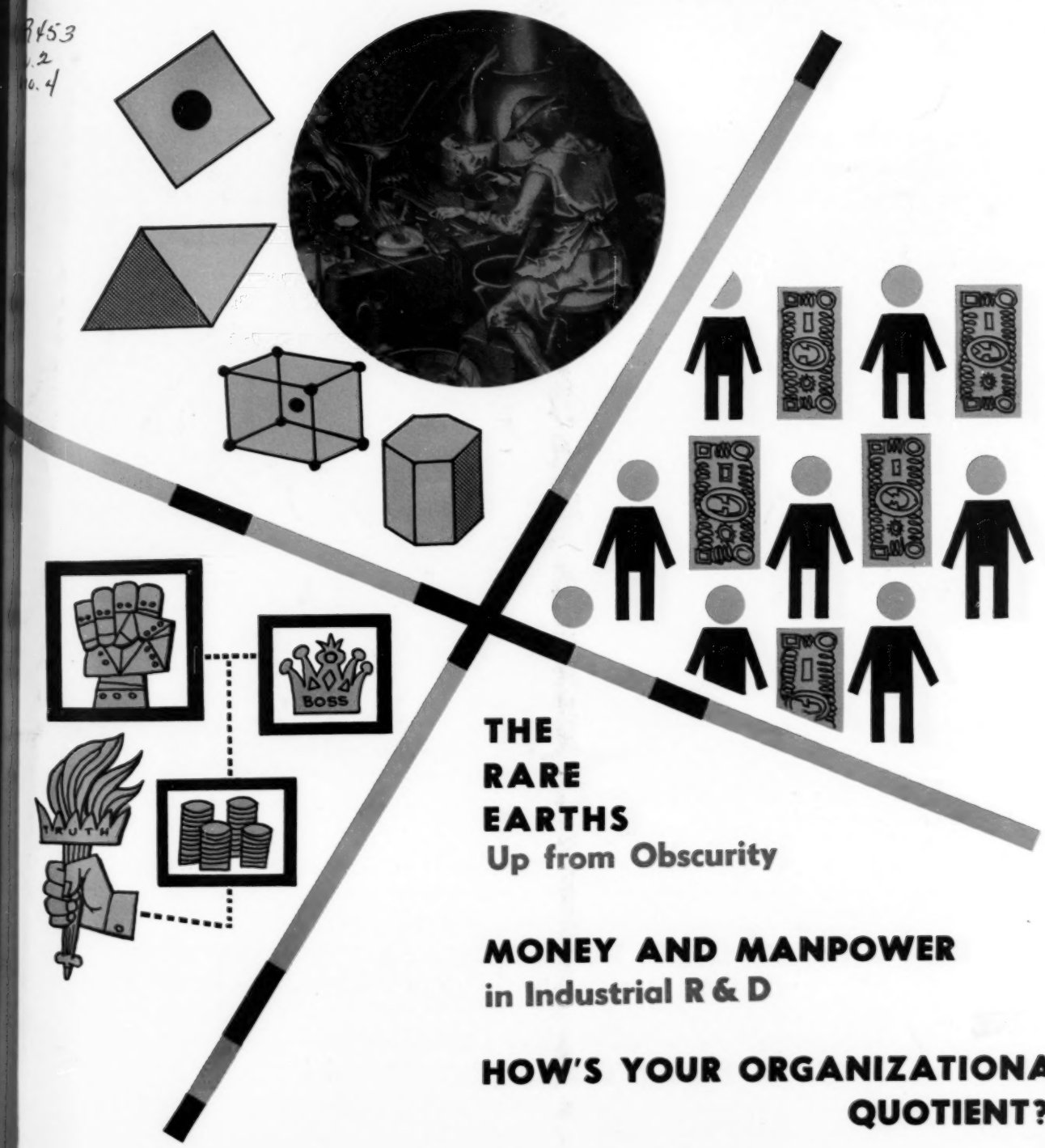


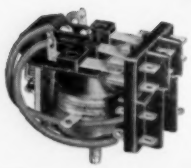
THE RARE EARTHS
Up from Obscurity

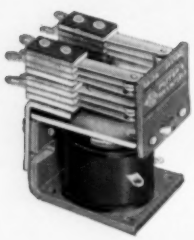
MONEY AND MANPOWER
in Industrial R & D

HOW'S YOUR ORGANIZATIONAL QUOTIENT?

LOW COST—HIGH QUALITY

Relays-a-Plenty





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FOR MORE INFORMATION CIRCLE 1 ON PAGE 48

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Navy adopts Cellulube fire resistant hydraulic fluids to safeguard aircraft elevator systems*

To minimize danger from fires and explosions that might hamper the operational efficiency of its great carriers, the U. S. Navy is now using Celanese* Cellulube 220, a straight chemical compound, as hydraulic fluid to activate deck-edge elevators.

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Cellulube 220 is one of a series of synthetic (non-petroleum) functional fluids developed for industry by Celanese in six controlled viscosities. These fire-resistant hydraulic fluids and cylinder lubricants provide a significant margin of safety wherever high temperatures and pressures may cause fire or explosion.

For additional information about the Celanese Cellulube series, write to Celanese Corporation of America, Chemical Division, Department **548-D,** 180 Madison Avenue, New York 16.

In Canada, Canadian Chemical Company, Ltd., Montreal, Toronto, Vancouver.

DECK EDGE ELEVATOR TAKES PLANE TOPSIDE. Cellulube 220 is being used in elevators of this type on the Shangri-La, Bennington and Ticonderoga. The Navy plans to install fire-resistant hydraulic fluids on all carriers.

OFFICIAL U.S. NAVY PHOTOGRAPH

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RESEARCH & ENGINEERING

FOR RESEARCH AND DEVELOPMENT MANAGERS

APRIL, 1956

VOLUME II • No.

SECTION 1

FEATURES

MONEY AND MANPOWER IN INDUSTRIAL R & D

In a statistic-conscious world, the interpretati of facts and figures as a prelude to action can b vitally important. Helen Wood's review of the fin ings of a Bureau of Labor Statistics survey o industrial R & D in the U. S. will provide you wi the background you need to spot trends and co ditions in your own area of work, as well as fu nishing a touchstone to the future. Miss Wood Chief, Branch of Occupational Outlook and Sp cialized Personnel, Bureau of Labor Statistics, U. Department of Labor.

THE RARE EARTHS — UP FROM OBSCURITY

Research and development personnel can no longe afford to neglect the Rare Earths. And as they fi new uses for them, production will expand an prices will drop in the classic manner. In ten years says Dr. R. C. Vickery, the Rare Earths will no be very rare. Dr. Vickery is Section Head of th Chemistry Dept., Horizons, Inc., Cleveland, Ohi

HOW'S YOUR ORGANIZATIONAL QUOTIENT?

This month Luis Villalon, our Management Affair Editor, poses eight key questions on research organ ization. If you can answer them affirmatively, th chances are you have a smooth functioning an productive environment—one which fosters the un stultified creativity so vital to research. But if some of your answers are negative, then perhaps you'd better reappraise your organizational set-u to prevent more serious problems later.

DEPARTMENTS

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LETTERS TO THE EDITOR .....
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PRODUCT PORTFOLIO .....

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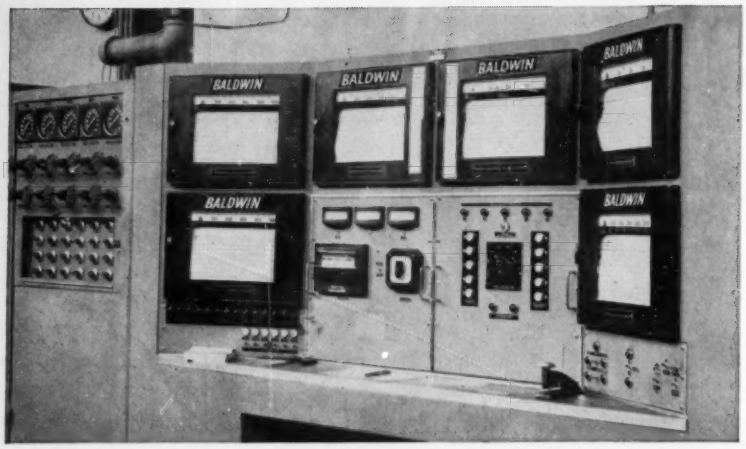

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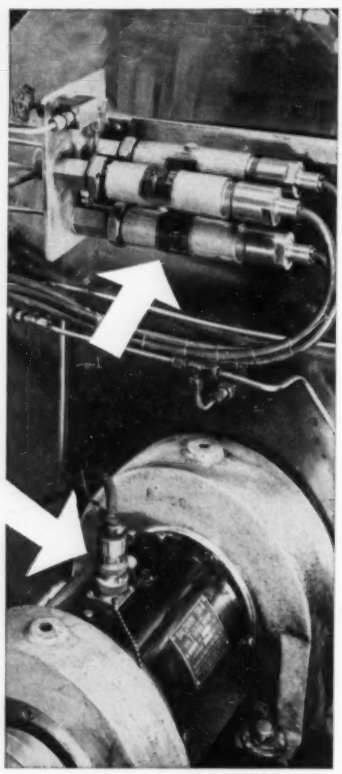

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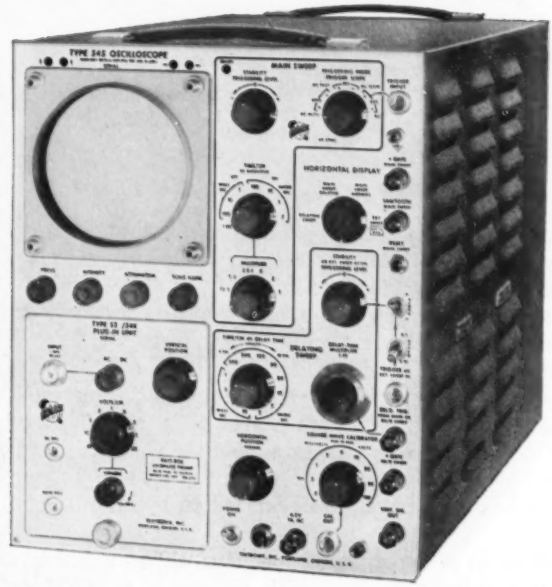
"ALL-PURPOSE" Oscilloscope...Type 545



The Tektronix Type 545 is a "fast-rise" oscilloscope with high-performance characteristics. It can write the answers to the most difficult problems in high-speed pulse analysis on its screen. You have only to read them off . . . with full assurance of their accuracy.

But the Type 545 is not a specialized instrument, useful only in fast-rise applications. It is easily adapted to a multitude of other applications by inexpensive plug-in preamplifiers. Along with its unique sweep-delay facility, this plug-in feature helps make the Type 545 the most versatile oscilloscope you ever hoped for. Is the Type 545 the answer to your instrumentation problem?

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0.02 μsec/cm to 12 sec/cm.
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FOR MORE INFORMATION CIRCLE 6 ON PAGE 48

R/E Marks

If you don't have access to data from the Atomic Energy Commission but still make a discovery relevant to an area classified by the AEC you are taking a "chance". This fact was brought out in a discussion on the status of our atomic energy industry. Senator Clinton P. Anderson (D., N.M.) questioned Lewis L. Strauss, Chairman of the AEC on the maintenance of secrecy in the advances of peaceful applications and uses of thermonuclear power. Strauss replied that peaceful thermonuclear reactors could also produce the neutrons for weapons and, therefore, a release of information might be of use to research carried on by an unfriendly power.

In answer to a hypothetical question about what would happen if a college student with no access to AEC data made a major discovery concerning neutrons, Strauss replied that a man "takes his own chances" if he publishes without first submitting his paper to the AEC for clearance. The situation was further clarified by William Mitchell, General Counsel for the AEC who added that the law constituted "no thought control" but would involve "a restriction on communication of ideas" when such ideas touched on national security. In this hypothetical situation, the scientist is under obligation to treat his discovery as classified information even though it may have originated with him.

Anderson's comment was that he now knew why the Federation of American Scientists has been asking that peaceful thermonuclear work be declassified. "There's an absolute iron curtain of thought . . . we didn't write that into law . . . The ultimate answer is that anyone who has a thought must first submit it to the AEC to see if they are allowed to think".

The incident above is no longer hypothetical. Donald J. Hughes of Brookhaven National Laboratory stated to the Moss Subcommittee on Government information that a scientist in England published an article in which he worked out one of the fundamental equations for the derivation of thermonuclear power. The scientist had no connection with the atomic energy program. At the same hearing before sub-committee chairman John E. Moss (D., Calif.) Dr. M. Stanley Livingston of M.I.T., Lloyd V. Berkner of Asso ated Universities, Dr. Elmer Hutchisson of Case Institute Technology and Harold C. Urey of the University of C cago agreed that we would make more rapid progress ward peaceful uses of the fusion of light elements if the pr ject were not behind security bars. All men agreed that e cessive security restrictions hampers the free flow of i formation upon which progress rests. Main points in the statements were:

- Not making the results of scientific experiments available results in duplication of work by other scientists who do not have access to classified information.
- When such work is declassified, it is generally out of date or not easily available.
- Keeping basic scientific information secret gives us only a short advantage that is offset by the disadvantages resulting from the lack of free discussion and critical evaluation by other scientists.
- The flow of information is restricted both into and out of Government agencies. New ideas and concepts are more important than secrets represented by weapons we now have.
- Current regulations vary from agency to agency. The confusion and bother of determining whether a colleague has the appropriate clearance and the right to know the information to be discussed is a deterrent to scientific progress and development.
- Publication in established scientific journals is the best method of informing scientists of new or recently declassified developments.

The men who made these suggestions are surely in position to evaluate the benefits and detriments of our cu rent security system. If their recommendations are heed and our security system revised to permit a freer inte change of information, we may find our technological pro ress up and our dollar costs down.

Harold C. Buchbinder

EDITO

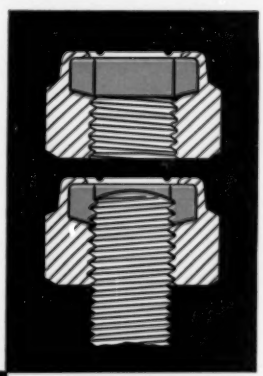
What's special about this STOP NUT?

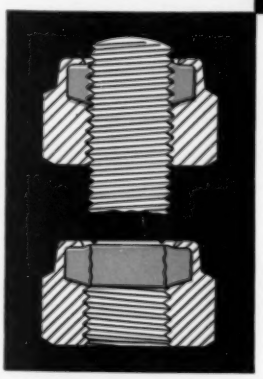
Several things make this nut unusual. For instance, you can "stop" it at any position on the threaded length of the bolt . . . or wrench it tight against the work where it protects bolt threads against corrosion and prevents liquid leakage. No matter where you leave it on the bolt, it will remain tight in that exact position, even though you subject it to heavy vibration and shock loads. But use a wrench on it and it comes off as easily as it went on. The red locking collar is nondestructive—does not gall bolt threads or remove plating. You can remove it and re-use it again and again.

What gives it its grip?

1 The locking collar is unthreaded and elastic. It has an inside diameter smaller than the major diameter of standard bolts.

2 The bolt impresses a mating thread into the collar and the resulting compressive forces exert a constant friction grip on the bolt. . . .





3 and exert a downward thrust bringing the lower flanks of the bolt thread into firm metal to metal contact with the matching nut threads, eliminating normal axial play.

4 Nut is removable and reusable . . . the Red Elastic Collar retains its grip after repeated usage.

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☐ Here is a drawing of our product. What self-locking fastener would you suggest?

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FOR MORE INFORMATION CIRCLE 7 ON PAGE 48

Developments

Accents on Research, 1956-57

Before 1956 has run its course almost 7 billions of dollars will have been poured out of corporate treasuries for industrial research. Much of this will be spent within the respective companies' own laboratories. But each year a larger proportionate share is going to the independent research laboratories whose work supplements that done internally. Many of the projects "farmed out" to the independent laboratories are jobs for which a company's own laboratory is not equipped or for which it does not have the proper personnel.

Accents on research during the remainder of 1956 and expected to carry over into 1957 fall into four distinct fields, according to Dr. Eugene Wainer, vice president and director of research of Horizons Incorporated, Cleveland industrial and governmental research organization.

One of the most important is the field of transition metals that includes uranium, thorium, titanium, niobium, tantalum, zirconim, hafnium and the group of 14 metals that comprise the rare earths (see p. 28 this issue). The other three fields which Dr. Wainer put at the head of the list are the graphic arts, powder metallurgy and foundry practices.

The work in the field of the atomic energy metals is not so much their use as fuel elements for atomic reactors, he explained, as it is in the problems of reprocessing the fuel elements. "What it actually amounts to is laundering these elements. After about five years as fuel element in a reactor, only one percent of the material has been transformed and 'burned'. The problem, however, is that that small fraction has created enough poisonous material so that the bulk of the valuable fuel remaining must be cleansed of this poison. How best to accomplish this reprocessing is the work that lies ahead in this field."

Foundry Practices

The field of foundry practice is wide open for technological improvements. The shell molding process made it possible to do away with the shakeout still necessary in sand castings and many other processes. While shell moldings have advantages over sand castings, there are limitations, too, as for example, size of castings and intricacies of shapes.

Many of these practices in casting plants are to some extent primitive. To illustrate this, it is possible to see in some plants fine material handling systems in overhead and in belt conveyors and, at the same time, see the basic practice of pouring molten metal by hand.

Probably one of the most important fields of work in the foundry is that of sands and binders. Binders that are gas-free or relatively gas-free are important to prevent gas inclusions, blowholes and porosity in the castings.

"This may sound completely contrary to the normal belief of expansion when heated, and contraction when cooled. But we are actually working on a casting sand that would contract when heated and expand when cooled," Dr. Wainer said. "Obviously, the advantage is that upon contraction on heating, the sand would make a tougher mold and would prevent crumbling. By the same token, its expansion on cooling would make for easier cleaning and reduce the shakeout problem after casting."

Graphic Arts

Problems in the graphic arts field are two-fold. One is a means of photographic reproduction which will maintain the quality of lithography and fine engraving and yet be far less costly.

Second is the need for high speed printing. According to Dr. Wainer, many means have been devised for computing and storing information at speeds much greater than those at which it can be reproduced on paper through printing. Extremely high speed printing can be used, for example, in the rapid printing of addressing labels for magazine subscription lists or the reproduction of data for business purposes.

Solutions to both these problems are being sought and the key is the reproduction of both the printed and photographic matter in dry media, that is, without the use of expensive and troublesome liquid chemicals.

Powder Metallurgy

Powder metallurgy will be developed to a great extent during the coming year. A number of plants produce parts and components today by the powder metallurgy method. But Dr. Wainer indicated that the difference is the manufacture of solid pieces by powder metallurgy as against porous and fibre metallurgy of powder.

One of the most recent developments in powder metallurgy is the production of fibrous metal. Techniques have been evolved to produce metal in long fibres with the

strength of the metal running the length of the fibre.

Other areas of powder metallurgy are being explored. One such avenue is the alloying of metals which would be difficult under the ordinary melting process. For example, if it is desired to mix lead and nickel, the lead would be molten and boil away long before the nickel was reduced to a molten state.

If an attempt were made to reduce each to a molten state prior to the mixing, a very bad mixture with segregation would result in addition to the loss of some lead before the temperature would be reduced to the point where the lead would once more solidify. Laboratory tests of such mixtures prove that it is not feasible from the type of alloy produced and from the time element required to produce it.

Yet testing has revealed that an alloy can be produced where the characteristics of each metal is required if the two are mixed as powder and then compressed by powder metallurgy techniques.

Powder metallurgy is invaluable in the making of parts of titanium and zirconium where scrap loss would boost the cost of the part too high. Since recovery of the scrap of these expensive metals is a tedious process and it is obvious that scrap loss should be held to a minimum, powder metallurgy of these metals is being pursued so that parts can be manufactured through this process with no practical scrap loss at all.

Rare Earths

The rare earths, found in the ashes of nuclear reaction, have been difficult to separate cheaply into their pure forms. When such separation of these elements from the compound states in which they are found has been economically accomplished, industrial and commercial application will follow.

Tantalum and niobium have been found to have remarkable anti-corrosion characteristics and their use in electronic as well as chemical equipment is drawing the attention of the research laboratories.

Titanium is presently being worked for jet aircraft components. Much work remains to be done to overcome enbrittling characteristics of the metal and processing scrap recovery of this costly metal.

French Electronic Skills Imported

By means of a newly formed company, Intercontinental Electronics Corporation, the products, design and development facilities of Compagnie Generale de Telegraphie Sans Fil and subsidiaries (CFS) will be available to American industry. Intercontinental was formed by CFS, the leading French electronic organization, and Airborne Instruments Laboratory, Inc., Mineola, N. Y. It will be staffed by personnel from both companies and be located in Mineola. In addition to adapting the products of CFS to the American market, Intercontinental will seek defense development contracts. It may sub-contract specific parts of a system to CFS in France or Airborne.

The organizing of this firm means that another channel has been set up for exchanging technical skills between the nations of the world. In recent months a number of European advances have been brought to the United States. A small French jet turbine has been licensed by Lycoming and a very fast Russian turbodrill has been licensed by Dresser Industries, a Texas oil drilling equipment manufacturer. In addition, CFS had previously licensed Raytheon to produce its "Carcinotron" backward-wave oscillator, which operates in the microwave range. Concurrently, a number of American developments are being exported through subsidiaries, commercial agreements or to meet NATO requirements.

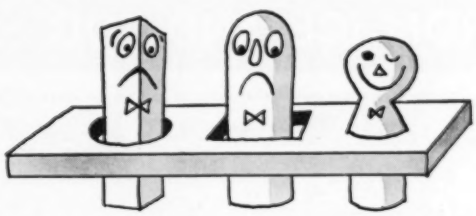
Job Analysis and the Misplaced Engineer

In the last five to ten years, the still inexact but promising science of "job analysis" has become a byword in American management circles. Most large industrial organizations rely on their personnel specialists to establish "man specifications" and "position descriptions" to help place candidates in the right supervisory and administrative slots.

According to Huxley Madeheim, Associate Professor in the Department of Business Administration at City College of New York, job analysis can also be used to help ease the shortage of trained and experienced engineers. Engineers, he says, are frequently misplaced; they may have been trained chiefly for research and development work, yet wind up selling technical products or in administrative work for which they may be ill-fitted. Worse, such men are often wasted on routine jobs such as computing and drafting.

Madeheim reports that a large public utility conducts a careful job analysis of requests to the Personnel Department for "engineers". In this way, the company can determine whether or not an engineering graduate is necessary. In addition, a personnel inventory showed that many engineers with the training and background for research and development work were being wasted on routine jobs. In some cases, the engineers were in sales and management jobs which could be handled by men of equal ability who lacked the technical training so urgently needed in research and development. Transfer of the misplaced men together with proper job analysis of open positions has made it possible for this organization to expand its research and development activities without hiring new engineering graduates.

Matching the Man to the Job



The personnel director of a large manufacturing organization says that the policy of his firm had been to hire only men with Doctorates in Mechanical Engineering as trainees for management jobs in their manufacturing plants. With a limited market they found it necessary to accept men with Masters' degrees in Mechanical Engineering, then men with Bachelors' degrees. Finally they were forced to take men with Electrical Engineering, Chemical Engineering and Industrial Engineering degrees. When this supply proved inadequate, they hired Masters of Business Administration and finally Bachelors of Business Administration. The company carefully observed the trainees and noted their progress through the ranks of the organization. Much to its amazement, the company found that many of the men with the less preferred degrees did better than those initially chosen. Why? According to Madeheim, the jobs had not been properly analyzed. Further, this firm did not have research and development jobs which require high technical

competence; it had management jobs requiring a broad variety of general skills.

Madeheim claims that for sales and management functions, graduates of accredited schools of business are more readily available than engineers—and in many instances, are better adaptable to such work. These men are trained in the same concepts of analytic thinking as engineers. While they may lack specific technical knowledge, they know more about the practical aspects of business than many engineering graduates. These non-technical business graduates can be taught enough to handle their jobs proficiently and to realize the necessity for referral of technical problems to technical men. They can devote their attention to business aspects of sales or management without the burden of purely technical matters. Madeheim's contention is that it would take as long to train the technical graduate in the sales or management aspects of the job, produce no better end results and remove yet another potential research and development man from his proper field.

Listening with the Third Ear

Sixteen noncompeting U.S. firms are in the unusual—and enviable—position of having a European pipeline to keep them primed on technological developments abroad. Because procedures for European liaison are now costly and haphazard, Armour Research Foundation of Illinois Institute of Technology will set up a European office to funnel ideas and techniques of potential value to the participating companies. Known as the European Technical Observation Group plan, the program will be extended to other firms since it is expected to have special appeal to small and medium-sized companies interested in keeping informed at a relatively small cost.

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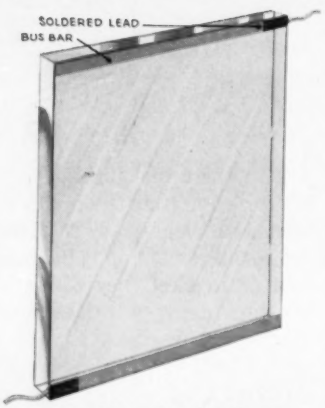

Liberty Mirror Electrical Coating 81-E eliminates fogging, icing, blurring and opaqueness under highly adverse conditions.

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FOR MORE INFORMATION CIRCLE 12 ON PAGE 48

The "Box" Method of Experimentation

Today's burgeoning research and development budg doesn't mean that most research directors and their co pany management are not acutely cost-conscious. Th larger the budget, in fact, the more closely it must be co trolled. One way to cut costs in the research unit is to im prove experimentation methods—with the added advanta of getting faster and more accurate results. The shorta of technical manpower also lends increasing importance t the development and use of newer methods of experimen tion in research.

One new method that has already proved its worth i chemical and related fields is the "Box" method of expe mentation, named for G. E. P. Box of Imperial Chemical I dustries who originated it.

The Box method is essentially an improved technique f dealing with a basic experimental problem—how to get th best or optimum result from a complicated process. It pr vides a systematic procedure for quantitatively determini the influence of operating conditions upon a process a quickly arriving at the optimum combination of operati conditions with a minimum of experimentation. It al yields a description of the process studied in terms of tangible mathematical relationship showing the quanti tive influence of the operating conditions involved upon th process. Consequently, it has had much appeal to chemis to whom the more usual methods of statistical experimenta tion have often seemed not too helpful.

To provide instruction in this technique of experimenta tion, the Chemical Division of the American Society f Quality Control is sponsoring a three-day course at the Ha vard Business School, Boston, Mass., May 20-23. For furthe information about the course write to Maynard S. Renne Dewey and Almy Chemical Company Division of W. R Grace & Company, 62 Whittemore Avenue, Cambridge 4 Mass.

How to Manage a Research Organization

Each industrial organization should perform fundamenta research up to the limits of its ability, says Dr. Elmer W Engstrom. Speaking before an IRE group in New Yor earlier this month on managing a research enterpris RCA's senior executive vice-president also discussed pro viding incentives to top engineers who do not want to be come administrators, two-man administrative teams, how to account for research, and the need for continually bring ing new blood into a research organization.

Performing fundamental research is good for morale according to Dr. Engstrom. In addition, a firm may rea unexpected practical benefits. However, the primary reason for basic research is for each company to fulfill its obliga tion to add to the human stockpile of knowledge on which its prosperity is based.

In outlining a problem in fundamental research, RCA leaves the assignment of details to the lowest administra tive level—only a broad area is indicated. When a research project is assigned, all participants down to the technician level are told what the company's objectives are. In this way none of the by-paths that might yield important re sults are missed.

Research on Equal Footing

Dr. Engstrom firmly believes that the research estab lishment must be on an equal footing with the other divi

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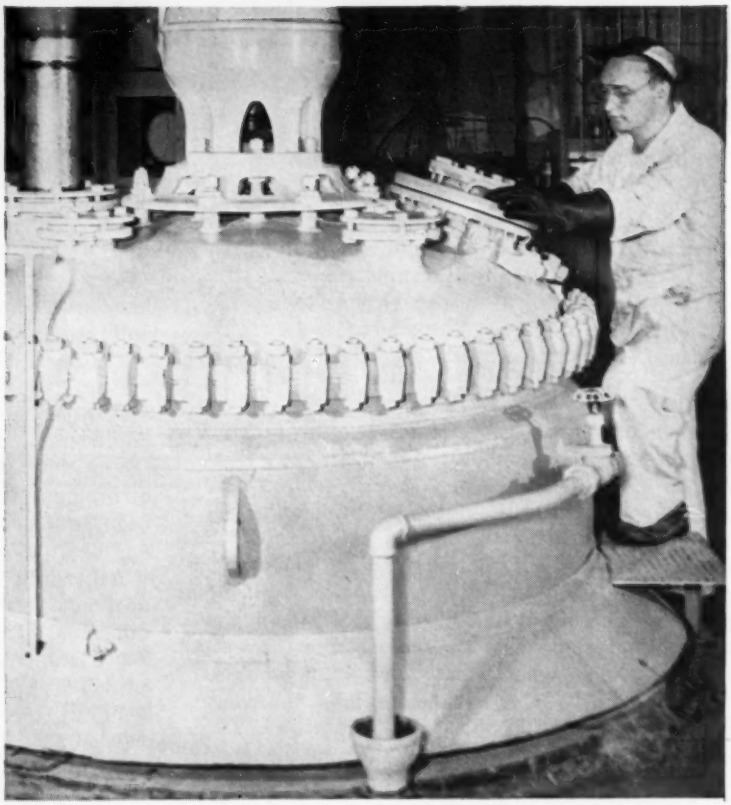

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sions of a company and have equal representation with top management. In RCA the Princeton research laboratories, which Dr. Engstrom leads, are not financially accountable to the operating branches. Royalties from licenses support the lab. Other firms sometimes finance their research by keeping an account of money believed saved by research and allowing the laboratory to draw on this account.

Two-Man Teams

As for the two-man administrative teams receiving attention from technical management, Dr. Engstrom still prefers to fill supervisory posts with one man combining both administrative ability and technical competence. He did point to the success of Philips in the Netherlands with three-man administrative teams. These teams, however, consist of men with different technical specialties.

Special Rewards

When queried about how RCA rewards engineers who do not want to become administrators, Dr. Engstrom said that they can be given salaries equal to that of the first three grades of supervisors, without the accompanying administrative duties. In addition bonuses as high as 30 to 40 percent of yearly salary may be given to engineers who perform conspicuously well.

Another policy is bringing in new blood directly from the universities. Dr. Engstrom feels that these men haven't been conditioned to know what won't work—and he feels this quality is an asset. At RCA's Princeton labs, the average age of research personnel is 35.

In discussing the many qualities necessary to the good researcher, Dr. Engstrom provoked a great deal of laughter when he added that the researcher "must have a wife who is satisfied to have him as a research man".

The Product Development Consultant: Offspring of Research

One of the curious phenomena of the business world in the last fifteen years has been the spectacular growth of management consulting firms. In 1953, for example, the "business doctors" grossed close to $500 million, according to the Association of Consulting Management Engineers.

This growth is partly due to the multiplying complexities of American business and partly to management's frequent need for objective help in solving the non-recurring problems it doesn't have time to tackle. The birth of new industries and new fields of specialization, accompanied by the usual growing pains, has also boomed the management counseling business.

Research and development as a comparatively recent organized activity is a case in point. In many individual companies, particularly those engaged in defense work and those seeking to diversify with new products, R & D has grown so fast that not even the most capable and efficient research director can cope with the myriad policy, program and organizational problems that arise.

Such management counselors as McKinsey & Company, Booz, Allen & Hamilton, and William E. Hill Company, among others, have stepped into the breech, with an assist for many a harried research executive—and with the blessings of top management. William E. Hill Company has been so active in this area that it has set up a separate division devoted solely to research and development problems.

New Types of Consultants

But the growth of R & D has done more than merely enhance the business of the traditional management consultant. It has also spawned other types of consultants, particularly those who deal in "new product development" and product diversification. One such firm is Technical Advisors, Inc., of Ann Arbor, Michigan, a group of scientists, engineers and administrators organized to help top managements with "techno-economic" problems in the fields of product and process development, product diversification, industrial engineering, and applied research in science and engineering.

According to an official of the firm, Technical Advisors does not perform the functions of other technical or economic consultants. Instead, it serves as counselor and client's representative in dealing with such consultants. Services provided include analyzing the client's problem, to help define it from a management viewpoint; obtaining the facts needed to determine whether a solution is technically and economically sound; where assistance outside the client's company is required, helping select the research, development or consultant organization (or individual) best qualified to carry out the specific project; providing liaison between the client and the outside organization. The latter includes supervision of the work, and keeping the client advised as to progress.

Product Development Corporation of Boston is another example of the "new product" type of consultant, with a twist. PDC's aim is to cull the best of hundreds of ideas and products from private inventors, then find the manufacturer whose production setup will fit such products. Currently, PDC is getting about 250 ideas a month from various sources in this country and abroad. And it has received inquiries from over a thousand different manufacturing organizations.

No one, no matter how capable the individual or organization, can guarantee profitable discoveries or inventions, says Thomas V. V. Atwater, Jr., Treasurer of PDC. This fact is the crux of a major headache facing the man responsible for a company's R & D activities. Atwater emphasizes his point by drawing an analogy: The best administration in the world applied to the finest research organization of geophysicists coupled with the most magnificent equipment that money can buy still cannot guarantee an oil strike.

Atwater points out that an outside independent inventor will often come up with a significant development in the electrical, mechanical, electro-mechanical, electronic or soft goods fields. No aggressive firm, he says, can afford to ignore him, no matter how much money is available or how carefully a given company tries to blanket the frontier of research in its particular field.

With its present clients, PDC generally works through a firm's research and development management and its findings usually supplement the work of this group. Because

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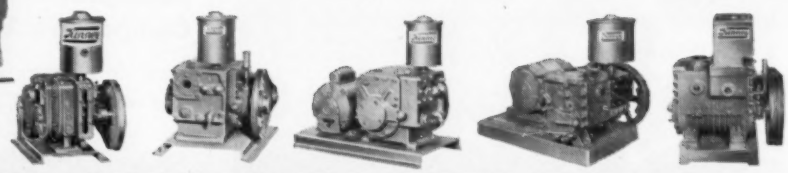

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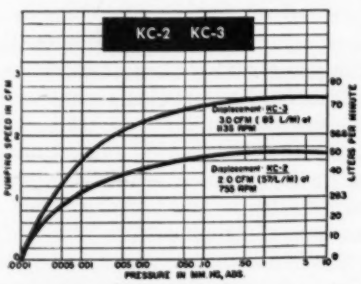
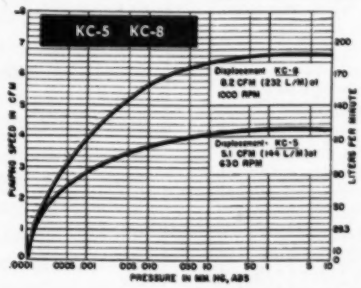
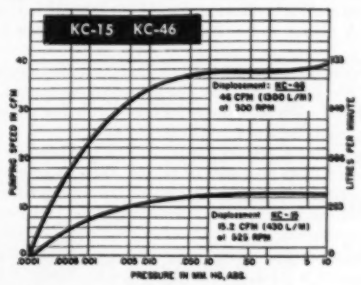
Free Air Displacement . . .	.95 Liters/sec.	1.41 Liters/sec.	2.4 Liters/sec.	3.9 Liters/sec.	7.2 Liters/sec.	21.7 Liters/sec.
RPM	755	1135	630	1000	525	500
Motor H.P.	¼	⅓	⅓	½	1	3
Motor RPM (syn.)	1800	1800	1800	1800	1800	1800
Oil Capacity	6 oz.	6 oz.	1⅓ pt.	1⅓ pt.	2 qt.	1 gal.
Shaft Diam.	¾"	¾"	¾"	¾"	¾"	1⅛"
Inlet Connection	¾" Screwed	¾" Screwed	1" Screwed	1" Screwed	2" Screwed	3" Screwed
Outlet Connection	None	¾" Screwed	1" Screwed	1" Screwed	1¼" Screwed	1½" Screwed
Net Weight, Complete . . .	70 lb.	78 lb.	140 lb.	148 lb.	300 lb.	585 lb.







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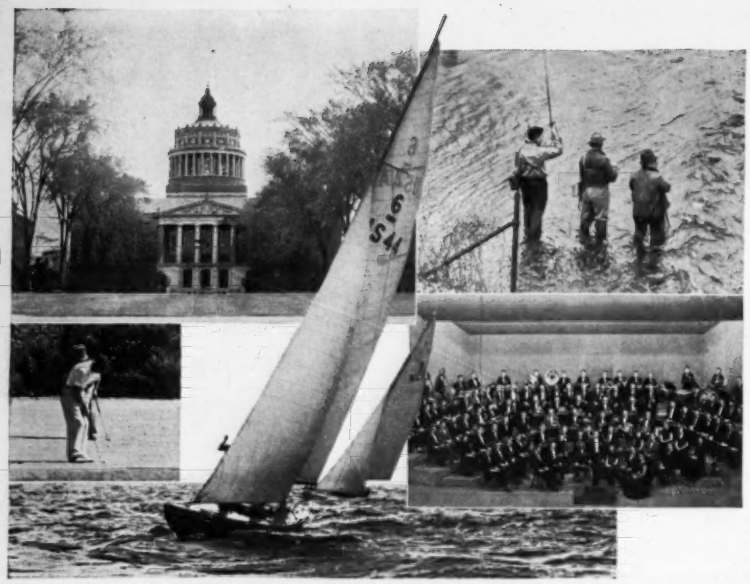

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The list below shows where there's room for you and your ideas to grow. Dig in now—with a detailed letter to Mr. Howard L. Foote, at the address below. We think you'll like what he has to say to you.

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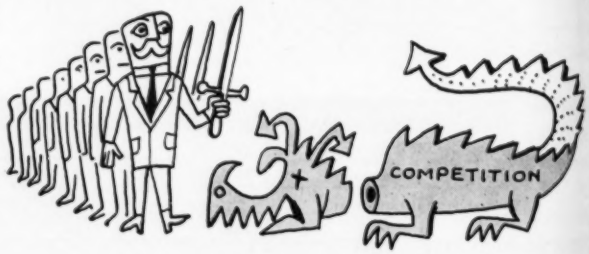
Neither Technical Advisors nor PDC has much competition now in the new product and diversification fields. But with more and more companies emphasizing such development, it seems likely that a number of similar organizations will spring up. If the success of PDC is any criterion, such services will fill a gap existing in many research and development programs.

Management: A Company's Only Real Competitive Advantage



In the long run the one real competitive advantage one company can hold over another is in its management group, said Ernest H. Reed, Manager, Education and Personnel, International Harvester Company, at a recent American Management Association conference.

Products, policies, equipment and processes can all be imitated or duplicated, he pointed out, "but a resourceful, imaginative management team is a unique and priceless asset to any company". Therefore, among management's prime responsibilities are to provide a continuing program to raise the level of effectiveness of all members of the management group and to provide opportunity and guidance for those with the potential and desire to assume ever-increasing responsibility at the various levels of management within any type of organization.

Management development programs for the upper levels of an organization are currently receiving increased attention throughout the business community. But, Reed declared, "All too often such efforts place undue emphasis upon techniques and forms with insufficient attention devoted to the analysis of actual needs and the establishment of practicable objectives."

In an effort to avoid this mistake, International Harvester's management development program was planned on the basis of a series of interviews with top company executives. They were asked what experience they considered as having been most helpful in developing their managerial abilities.

Four influences emerged as the most significant: (1) work experience involving some degree of business management during the educational years; (2) some type of experience in speaking before groups; (3) exposure during the early years of employment to a superior who tended to expect a great deal and to delegate responsibilities; and (4) assignment to highly important or sensitive projects—the kind that demand thorough investigation, analysis and recommendations.

Management in Depth

At the same meeting, Roy C. Ingersoll, Chairman of the

Board and President, Borg-Warner Corporation, stressed the need for building "management in depth". No manager today, he said, has any good excuse for not building a firm line of succession behind him.

Some decades ago, Ingersoll noted, there may have been some slight excuse for failing to build management in depth. For management in the early days of the free enterprise system was purely an art. But today management is much more complicated and technical. And, while still an art, it is also a science. "As a science, it can be taught to any who can read or write and who have the willingness to learn."

To build management in depth means to have a reservoir of capable sub-executives who are trained and ready to step into the shoes of their superiors. A company, Ingersoll advised, should build management in depth in every area that affects sales and earnings and services to customer and the public. Obvious though this seems, executives often fail to do it, for three principal reasons: The executive may be apathetic about the future of his company or his department; he may also be afraid to train and promote subordinates who could prove so capable that they might take his job. Or he may be so busy with the day-to-day operation of his business that he lacks the time or the patience to teach those around him.

For Qualified Scientists: Temporary Memberships in NYU's Institute of Mathematical Sciences

With the demand by many companies (particularly those using complex electronic computing equipment) for mathematicians, the future for these scientists is indeed rosy. To help relieve the nation's shortage of scholars in applied mathematics, New York University's Institute of Mathematical Sciences will launch a new program next fall.

Under the program, the Institute will offer several temporary memberships to qualified scientists holding the Ph. D. degree. The temporary members—mathematicians, physicists, engineers and others—will spend one or two years at the Institute with complete freedom to select their own activities. They will receive a stipend commensurate with their status, and will have opportunities to participate in advanced graduate courses, research seminars, and research projects. They may also use computational facilities, including a UNIVAC operated by the Institute for the Atomic Energy Commission.

Forecast for the Forty-Plus Executive

The "Forty-plus Club" got a shot in the arm recently when Glen B. Warren, vice president of the General Electric Company, said executive opportunities for older men are on the rise. Speaking before the diamond jubilee annual meeting of The American Society of Mechanical Engineers, Mr. Warren went on to say that the increasing growth and complexity of American business is leading to a greater demand for more and better managers. "Further," he added, "experience indicates that the vast majority of successful managers in business generally are mature men in their late 40's or 50's, sometimes running into the 60's." On the other hand, he pointed out, "A careful history of great technical contributions indicates that they are frequently originated and brought forth by younger men, averaging in fact, in their 30's. It is the exception to have outstanding contributions by a technical specialist in his mature years."

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Materials Bottleneck Atomic Power

"The prime bottleneck in achieving efficient and low-cost nuclear power is the inability of available materials to function adequately." According to Stanley B. Roboff, manager of industrial coordination for Sylvania's Atomic Energy Division, nuclear fuels must be greatly improved. In other new developments in the atomic industry it has been revealed that atomic radiation may be used to process sewage and that the danger from nuclear power reactors is not an explosion but poisoning of an area by radioactive materials.

Roboff believes that to obtain the higher thermal efficiencies necessary to produce low-cost power, nuclear reactors must be operated at higher temperatures than are possible at present. He called for the following advances to be made for atomic power to become generally available:

- reduction of cost of certain important reactor materials such as zirconium, beryllium and heavy water.
- development of new reactor materials capable of withstanding severe corrosion conditions and high temperature ranges.
- new forms of moderating materials so that moderation of neutron velocities can be achieved in smaller volumes.
- new and better shielding aggregates, especially for packaged power and mobile reactors to lessen their weight and increase their usefulness in confined spaces.
- a low-cost fuel recovery process.

Sterilizing Sewage

Los Angeles is investigating the use of atomic radiation in improving its sewage system, according to Mayor Norris Poulson. As part of the plans for a $60,000,000 reconstruction of the city's sewage system, Nuclear Science and Engineering Corp., Pittsburgh, Pa., is carrying out experiments to determine if decontamination of sewage is cheaper by nuclear radiation than present methods. If this new application for atomic materials becomes practical, then radioactive waste materials can be utilized instead of being disposed of at sea or by burial.

Reactor Hazards

A report on how the public would be protected financially in the unlikely event of an atomic reactor disaster has been released by the Legislative Drafting Research Fund of Columbia University. Much concern has been expressed lately about how to insure a power reactor. The insurance industry has marshalled about $60,000,000 for liability coverage in the nuclear field. Although prepared by a group of law professors and lawyers, the report revealed much information about the possibilities of a nuclear power reactor disaster and what it would be like.

The report stressed that the reactor is not an atomic bomb. If a reactor "ran away", the resulting explosion would be of a much smaller order of magnitude than that from an atomic bomb. The real danger is from the discharge of radioactive material into the local environment. To date 25 nuclear reactors have been operated for a total of hundreds of thousands of hours without accident. The report calls for government aid in financing insurance for power reactors.

Running Against the Tide, Selas Avoids Diversification

At a time when the password in American industry is "diversification", Selas Corporation of America has been avoiding diversifying its products. The reason is the great diversity of its market; wherever high-heat equipment is required in industry. Betting on a growing market for its forte, Selas has just moved into a modern, suburban plant and laboratory at Dresher, Pa., from a smaller, over-crowded building in downtown Philadelphia.

Greatly expanded laboratory facilities will enable Selas to take on more confidential applied-research projects for its customers, a side-line that has grown steadily in the last few years. These extensive research facilities are necessary for a company that has to come up with a new design for every sale of equipment. According to A. A. Furczyk, Selas' Chief Development Engineer, the laboratory also serves as a training school for newly hired young engineers. No engineering school in the nation trains engineers in the special skills this firm needs.

Selas has pushed rapid heating to high temperatures as opposed to heat "soaking" for long hours common for years in most industries. To develop high temperature burners, Selas has become expert in ceramic technology. This expertness has led the firm to diversify to some extent (about 20% of total sales) by producing special filter ceramics for the chemical and biological laboratories. One of these filters is the key element in an artificial "heart" which the firm developed in collaboration with an experienced physician. In fact Selas is known to more people for its ceramic filters and artificial heart than for its main line of equipment.

Rejected Home-Heating Line

Although Selas did profitably follow its engineering know–how into the field of chemical filters, it rejected another opportunity to diversify. A few years back, according to Frederick O. Hess, president of Selas, his engineers developed a new design in home-heating equipment. After some consideration, the firm decided not to go into a new field, because it lacked the consumer marketing experience and the production facilities.

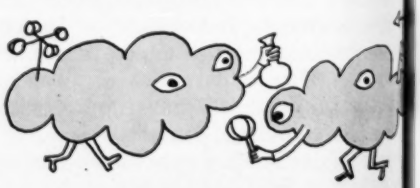
Following its main engineering tenet of high temperature heating, Selas is now investigating burner materials that will stand higher and higher temperatures. Cermets are receiving a great deal of attention because of their great structural strength at high temperatures. As a result the wide range of American industry that requires closely controlled high heat will eventually be offered more and more compact heating installations to do their job in less and less time.

Increase in Sales by OTS

American scientific organizations and industries last year purchased 64.8 percent more Government research reports through the Office of Technical Services, the agency set up by law to collect reports of Government-sponsored research, reproduce them and disseminate them to science and industry, than in 1954. This indicates increased awareness of these sources of technical information and their value in the nation's research and development programs.

Two monthly publications which abstract these reports are handled by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. Subscriptions: *U. S. Government Research Reports*, $6.00 a year; *Technical Reports Newsletter*, $1.00 a year.

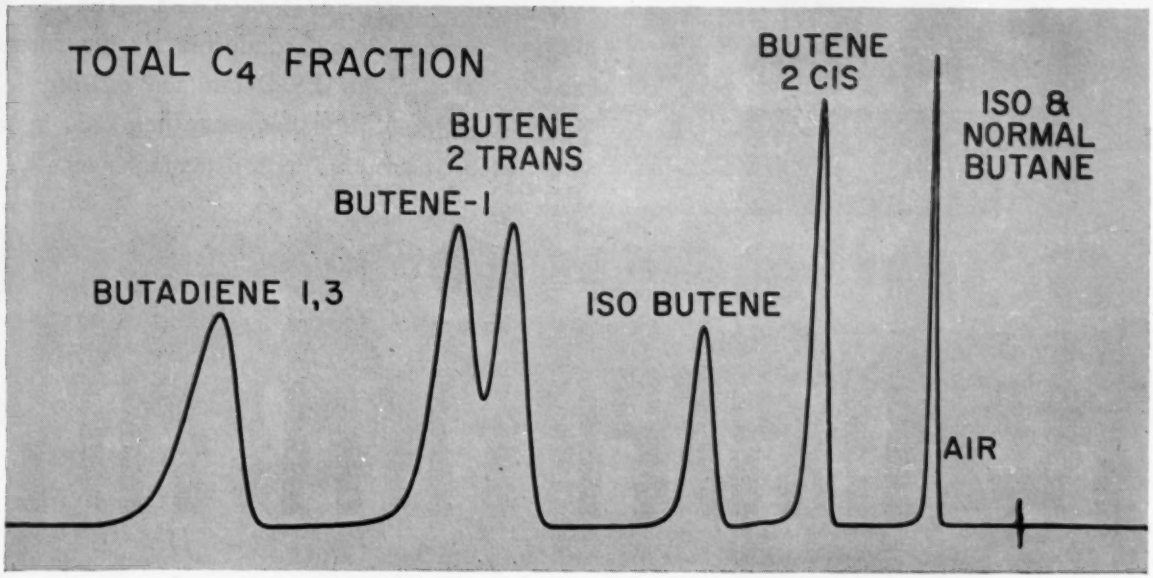
Smog Research



The troublesome smog problem in the nation's large cities can be solved. Pittsburgh and St. Louis proved that. Now it seems to be Los Angeles' turn, where a heavy blanket of smog (smoke and fog) frequently smothers the city for days at a time, creating eye irritation, disagreeable odors, reduced visibility and plant damage.

The Southern California Edison Company has appointed Dr. A. J. Haagen-Smit of California Institute of Technology to head its air pollution control research program. Initial objectives of the research will be to find means of controlling sulfur products and other gases in stack emissions and to reduce greatly the discharge of particulate material into the atmosphere.

The Cal-Tech scientist's laboratory experiments have established a number of the accepted basic theories which serve as the foundation for today's many-sided research into the causes of air pollution.



New P-E Model 154 Vapor Fractometer gives you

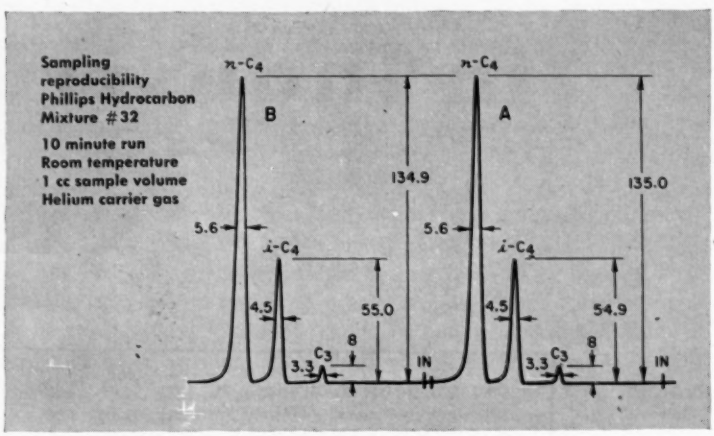
BUTENE SEPARATION IN 15 MINUTES!

Analysis extremely difficult by ordinary methods

Employing the principles of gas chromatography, P-E's new Model 154 Vapor Fractometer is a revolutionary advance in the field of gas and volatile-liquid analysis. Quantitatively it is fast, precise, uncomplicated to operate, extremely simple in calculation, and above all, many times less expensive than distillation columns, mass spectrometer, or any other instrument for the purpose. Qualitatively the instrument gives extremely clean separations — even of components and isomers which cannot be separated by ordinary methods.

The butene separation shown above demonstrates the instrument's ability to take advantage of the physical properties of the sample (in this instance, the chemical complexing with the stationary phase) to achieve the desired separation. Other column materials will readily resolve the paraffin hydrocarbons.

Vapor fractometry is the fastest, simplest, most inexpensive method of analysis in existence today.



The remarkable reproducibility of the Vapor Fractometer is shown in the two runs, A and B. Note that the quantitative values of A, B, and the Phillips analysis agree to small fractions of a percent.

MOLE % CONCENTRATION

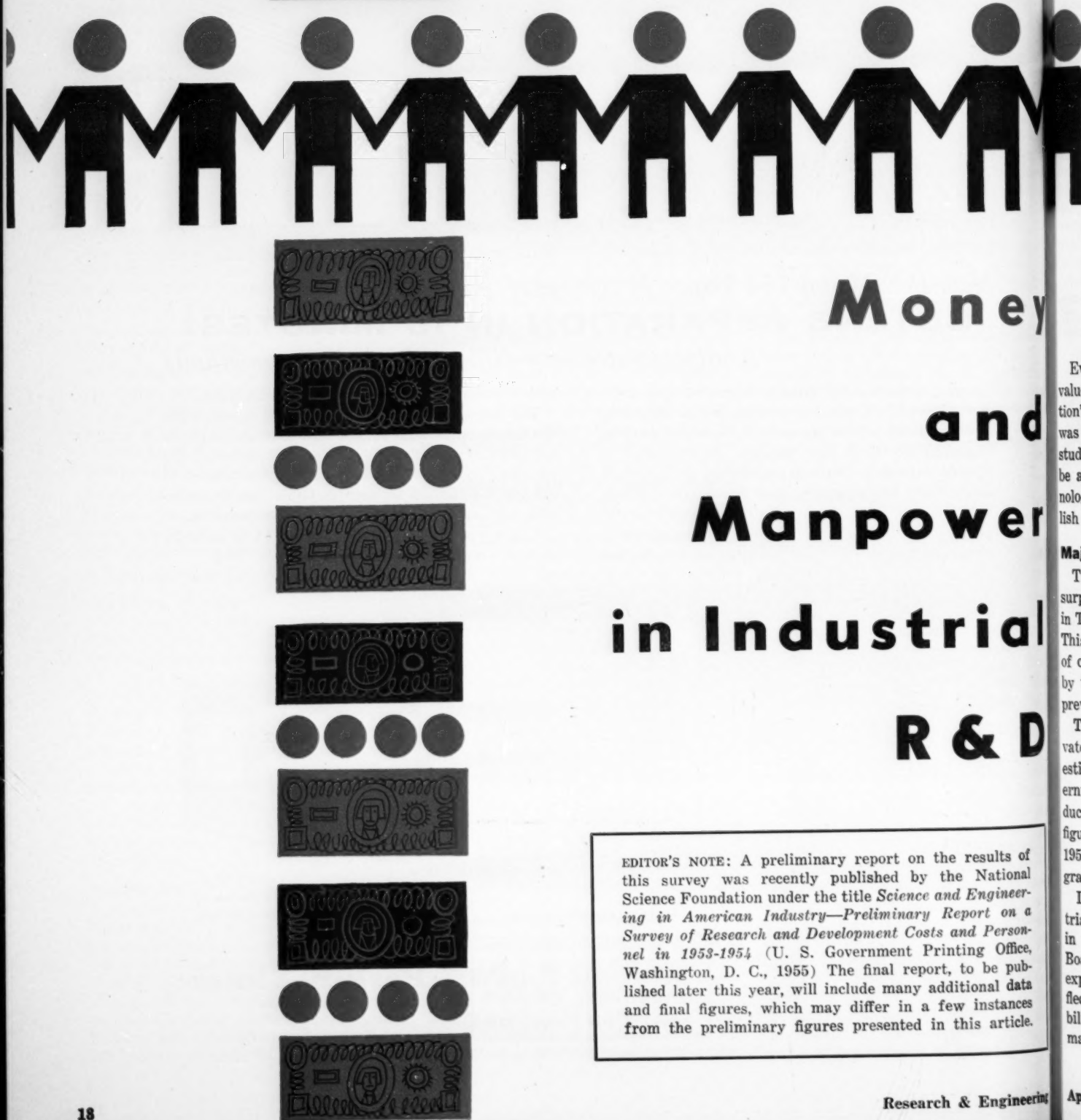
	Run A	Run B	Phillips
Propane	2.56	2.56	2.55
Isobutane	24.00	24.05	23.98
N-butane	73.44	73.39	73.47

This is the Model 154 Vapor Fractometer — price, $2200.00 including recorder. Send for descriptive bulletin.

Perkin-Elmer
CORPORATION
Norwalk, Connecticut

FOR MORE INFORMATION CIRCLE 14 ON PAGE 48

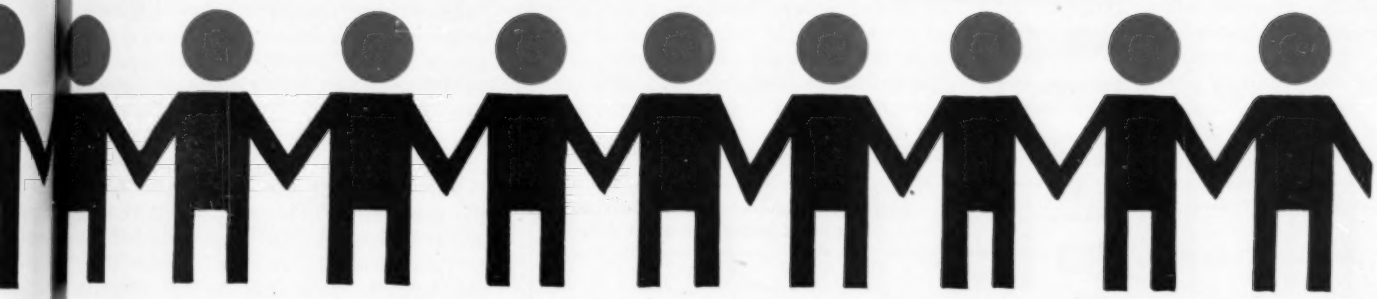
Here's a yardstick for determining how your company's R & D effort compares with others. The results of this nation-wide survey, conducted by the Bureau of Labor Statistics of the U.S. Department of Labor for the National Science Foundation, may help you in selling your research program to top management.



Money and Manpower in Industrial R & D

EDITOR'S NOTE: A preliminary report on the results of this survey was recently published by the National Science Foundation under the title *Science and Engineering in American Industry—Preliminary Report on a Survey of Research and Development Costs and Personnel in 1953-1954* (U. S. Government Printing Office, Washington, D. C., 1955) The final report, to be published later this year, will include many additional data and final figures, which may differ in a few instances from the preliminary figures presented in this article.

Helen Wood



Everybody these days is talking about the need for research and its great value. But until the Bureau of Labor Statistics made its survey of the nation's R & D effort for the year 1953, no one actually knew how much work was really being done. With this first comprehensive survey as a base, future studies can be made and trends isolated; the nation's technical leaders will be able to formulate better judgments with respect to the direction of technological programs and company management will be better equipped to establish sound R & D policy and budgets.

Major Findings

The extent of R & D activities in private industry shown by this survey far surpasses that indicated by earlier data. Highlights of the survey are shown in Table 1. More than 15,000 companies were found to be engaged in R & D. This figure is exclusive of organizations having less than eight employees and of commercial laboratories and the few other types of businesses not covered by the survey. It is several times that suggested by the most comprehensive previous data.

The dollar estimates derived from the survey are more astronomical. Private industry's R & D activities cost approximately $3.7 billion in 1953. When estimates of the cost of research conducted by educational institutions, government agencies and other types of organizations (from other surveys conducted or sponsored by the National Sciency Foundation) are added to this figure, the total national cost of R & D is found to have exceeded $5 billion in 1953. Work done by private industry accounted for at least two-thirds of this grand total.

It is interesting to compare the $3.7 billion figure on the 1953 cost of industrial R & D with the 1951 figure of not quite $2 billion for companies included in the survey in which BLS cooperated with the Research and Development Board. The difference between these two figures is due in part to the marked expansion in industrial research between 1951 and 1953. However, it also reflects the fact that this is the first industrial research survey based on a probability sample of companies, representative of both manufacturing and nonmanufacturing industries. It is, there–

(continued on page 20)

TABLE 1

Summary of Major Findings of NSF-BLS Survey

Number of Companies Engaged in R & D during 1953	15,000
Number of Scientists and Engineers Employed in R & D work (January, 1954)	157,000
Total Number of Persons in R & D Work (including technicians, administrative and other personnel)	400,000
Cost of Private Industry's R & D Activity During 1953	$3.7 billion
Total National Cost of R & D During 1953 (including research and development done by educational institutions, government agencies, etc.)	$5 billion
Percentage of R & D Work Done by Private Industry	66%

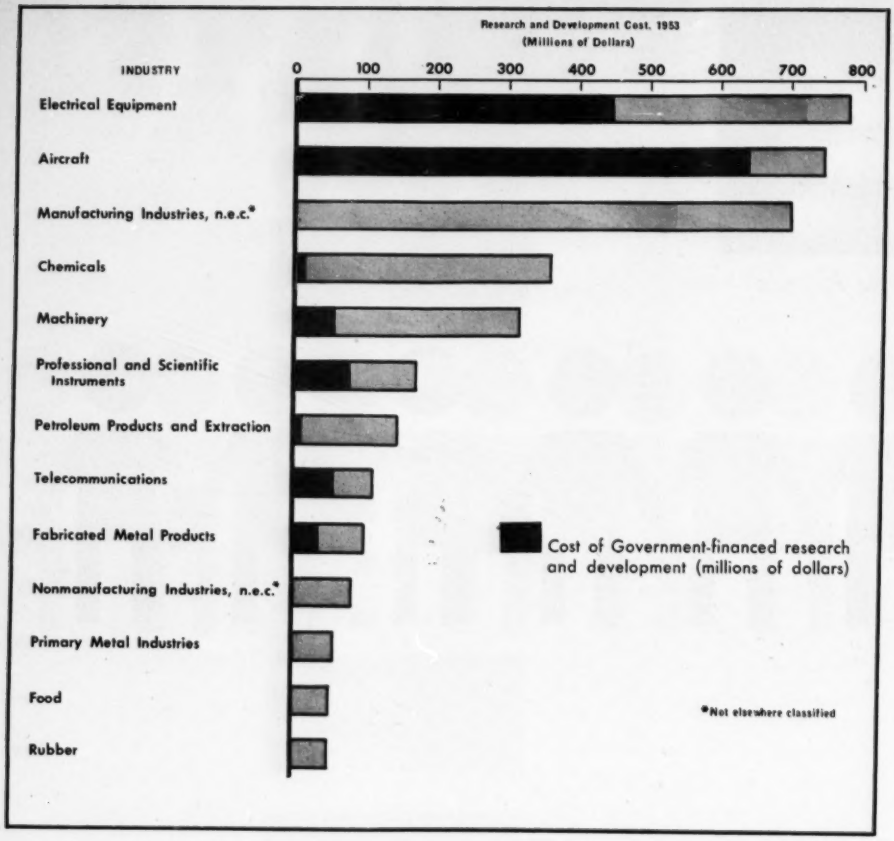


Fig. 1. Manufacturing industries on the third bar of the chart include the automobile industry. (All charts courtesy of the Bureau of Labor Statistics.)

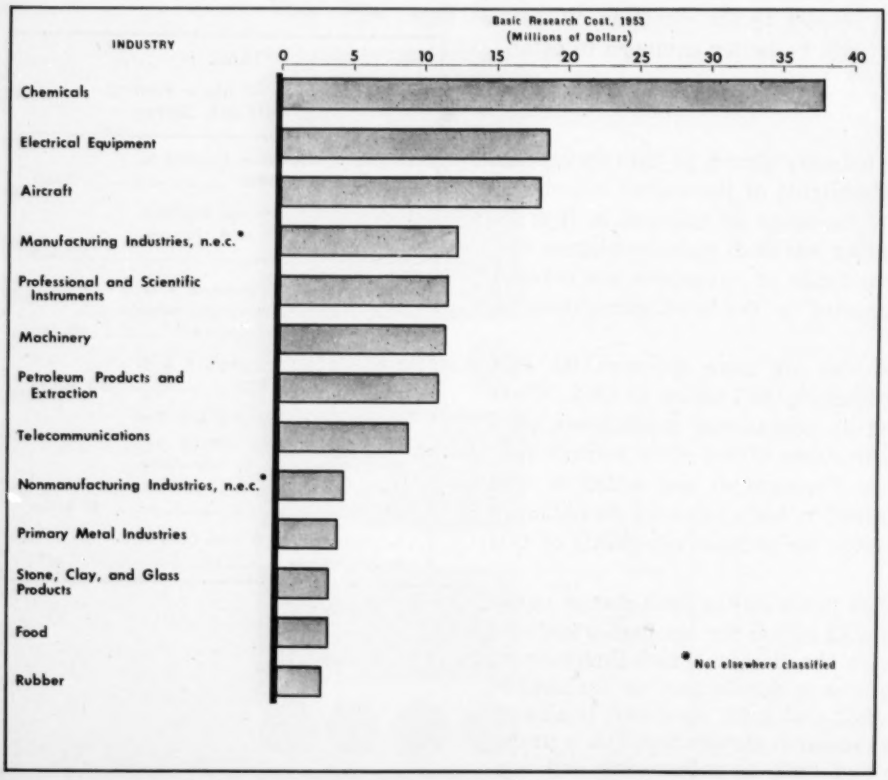


Fig. 2. The total expenditures for basic research by industry in 1953 was about $150 million.

fore, the first such survey which has yielde estimates for industry as a whole, n merely for the companies supplying data

R & D Cost by Industry

In considering the findings in Fig. 1 o research costs in different industries, th basis of the BLS industrial classificatio should be borne in mind. In this survey the reporting unit was a company, an each company's entire R & D progra therefore had to be classified in a singl industry. Even in statistics based on estab lishment data, industry totals generally in clude some data relating to secondary pro ucts within the purview of other industries In the present study, this problem wa greatly magnified, especially in the case o multi-unit companies with many differen products or integrated operations.

Fortunately, it was possible to explore the problem of industrial classification o research activities in connection with in terviews held with officials of some 200 o the largest companies—to ask their co operation in the survey and obtain infor mation on a number of questions impor tant to the development of national scienc policy. During these interviews, company officials were asked to estimate roughly what percentage of their company's R & D cost fell in major industries other than the one which represented the company's main field of activity. As expected, much crossing of industry lines was found, ex cept in the chemical industry. Practically all research done by chemical companies is on projects normally classified in that in dustry. On the other hand, many companies classified in other industries indicated that some of their research work related to chemicals and allied products. The conclu sion is that the data on research costs for companies in the chemical industries un derstate the total cost of research on chemi cal products. It also appears that the cost figures for the electrical equipment indus try, gigantic as they are, understate the total cost of research on electronic and electrical products.

Government-Financed Research

Obviously, the industries with the largest amount and proportion of Government-financed research are those most directly related to the defense effort. Certain in dustries, however, especially chemicals and petroleum, have made a greater contribu tion to defense research than the Govern ment cost figures suggest, since part of their large company-financed research pro grams have had a bearing on defense prob lems. It should be noted also that all data from the present survey are exclusive of several Government-owned research centers operated by private industry (since these centers are included in the National Science Foundation's separate survey of R & D con ducted by the Federal Government). If these centers were included in the statis-

tics, the proportion of R & D cost shown to be federally financed would be raised for several industries, especially chemicals.

Basic Research

Though basic research is recognized as the ultimate source of scientific knowledge, little information has been available so far about the amount of such research done by industrial concerns. Estimating the cost of basic research conducted by industry was therefore a major objective of the survey. Acute definitional problems were involved in this undertaking, however, since there is no definition of basic research which is generally agreed upon and the line between fundamental and applied research is difficult to draw. After many conferences with leaders in the field of industrial research, the following wording was decided upon as most suitable for obtaining information on private industry's basic research activities: *Basic or fundamental research—Projects which are not identified with specific product or process applications, but rather have the primary objective of adding to the overall scientific knowledge of the firm.*

This definition and the data reported in accordance with it reflect a concept of basic research, characteristic of private industry, which is considerably different from and broader than that customary in academic circles. Nevertheless, the cost of basic research performed by private industry was found to be slightly under $150 million in 1953. (Fig. 2 shows the relative amounts spent for basic research by various industries). This figure represents only four percent of the estimated total R & D cost of $3.7 billion.

Distribution and Costs

As has been mentioned, the number of companies conducting R & D is far greater than was suggested by any previous data. This finding results mainly from the probability sample of small companies, which were not adequately represented in previous surveys.

About 8500 manufacturers with 8 to 100 employees and 3300 with 100-499 employees conducted R & D during 1953 (as shown in the bar chart section of Fig. 3). These companies represented about 85 percent of all manufacturing concerns with eight or more employees participating in R & D work. The lowest and shortest bar in the chart stands for 310 companies with 5000 or more employees, which represented only two percent of all manufacturing concerns found to have R & D programs.

The "pie-shaped" diagrams in Fig. 3 add another dimension to the picture. They show that the percent distribution of companies conducting R & D rises sharply from one size group to the next as absolute numbers decline—from eight percent of the manufacturers with less than 100 employees up to 95 percent of those with 5000 or more employees.

It is an axiom of industry analysis that the relatively few big companies have the lion's share of employment, sales, earnings, assets and any other statistics correlated with the scale of industrial activity. Thus, the slightly over 300 companies with 5000 or more employees accounted for 40 percent of all manufacturing employment, whereas the nearly 12,000 firms with less than 500 workers accounted for only about 35 percent of the total employment figure (see Table 2).

This distribution of employment may be regarded as a yardstick against which to gauge the concentration of R & D costs in large companies (see Table 2). The companies with 5000 or more employees did over 70 percent of the R & D work (measured in terms of 1953 cost), a far higher percentage than their proportionate share of employment. In contrast, companies with less than 500 employees did only a little more than 10 percent of the R & D work, though they had about 35 percent of the employment.

Employment of Scientists and Engineers

Despite certain limitations, the survey confirms that private industry is by far the largest field of employment for the nation's scientists and engineers. About 550,000 engineers and scientists were found to be employed in the surveyed industries in January 1954, many more than are on the payrolls of Government agencies, colleges and universities, and all other types of employers taken together.

As Table 3 shows, employment in R & D was largest, in absolute numbers, in the

TABLE 2.—*Percent distribution of R & D cost and of total employment by size of company, for manufacturing companies.*

Size of company	All employees, January 1954	All scientists and engineers, January 1954	Research and development cost, 1953
All sizes of companies	100.0	100.0	100.0
Less than 100 employees	15.8	9.4	4.2
100 — 499 employees	19.3	10.2	6.1
500 — 999 employees	8.3	4.9	3.9
1000 — 4999 employees	17.3	14.5	14.0
5000 or more employees	39.3	61.0	71.8

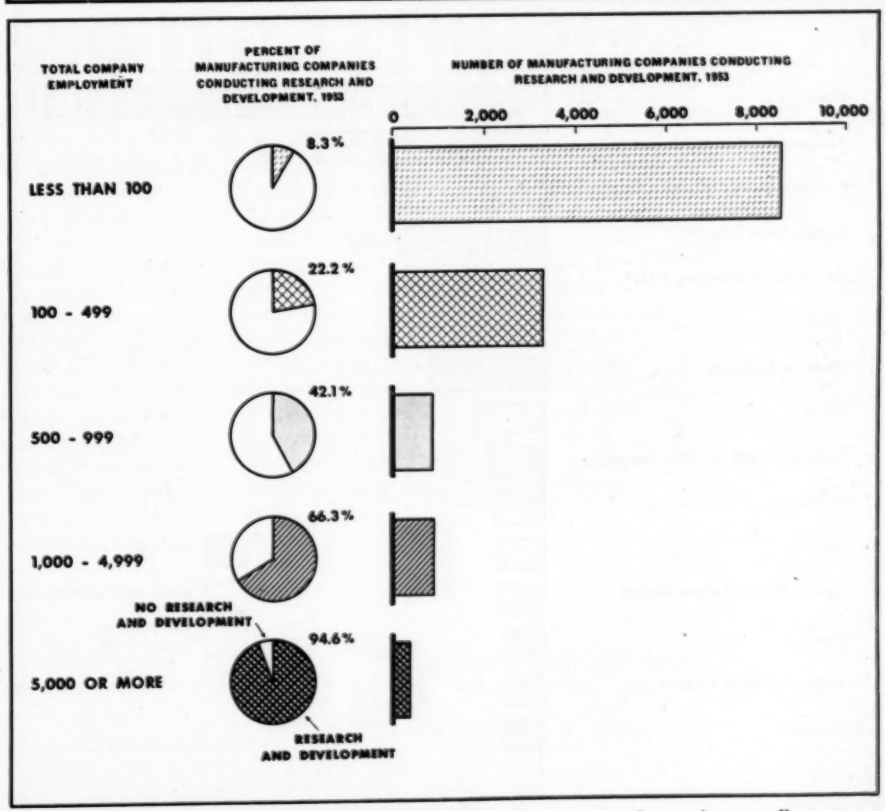


Fig. 3. Percent of companies conducting R & D is greater among large than small companies though absolute number is smaller.

two largest professional fields—engineering and chemistry. Relatively speaking, however, R & D activities assumed greatest importance among the biological scientists and physicists, about two-thirds of whom were found to be engaged in such work.

The range of industries utilizing scientists and engineers is very wide. Engineering employment is especially widespread; many members of this profession were found to be employed in all major branches of manufacturing and in many nonmanufacturing industries. On the other hand, over half of all engineers in industries covered by the survey were in metalworking industries.

TABLE 3.—*Scientists and Engineers Employed in R & D and Other Activities in Private Industry, by Occupational Group, January 1954.*

OCCUPATIONAL GROUP	TOTAL SCIENTISTS AND ENGINEERS	R & D SCIENTISTS AND ENGINEERS	
		Number	Percent of total
Total 1	553,800	157,300	28.4
Engineers	408,700	105,100	25.7
Chemists	60,000	26,800	44.6
Metallurgists	11,300	3,500	30.6
Earth scientists	9,800	700	7.1
Physicists	7,500	4,800	63.4
Mathematicians	6,400	2,500	38.6
Agricultural scientists	4,200	800	20.0
Medical scientists	3,000	1,000	34.2
Biological scientists	2,400	1,600	67.8
Administrators	33,700	9,300	27.7
Others	6,600	1,100	17.3

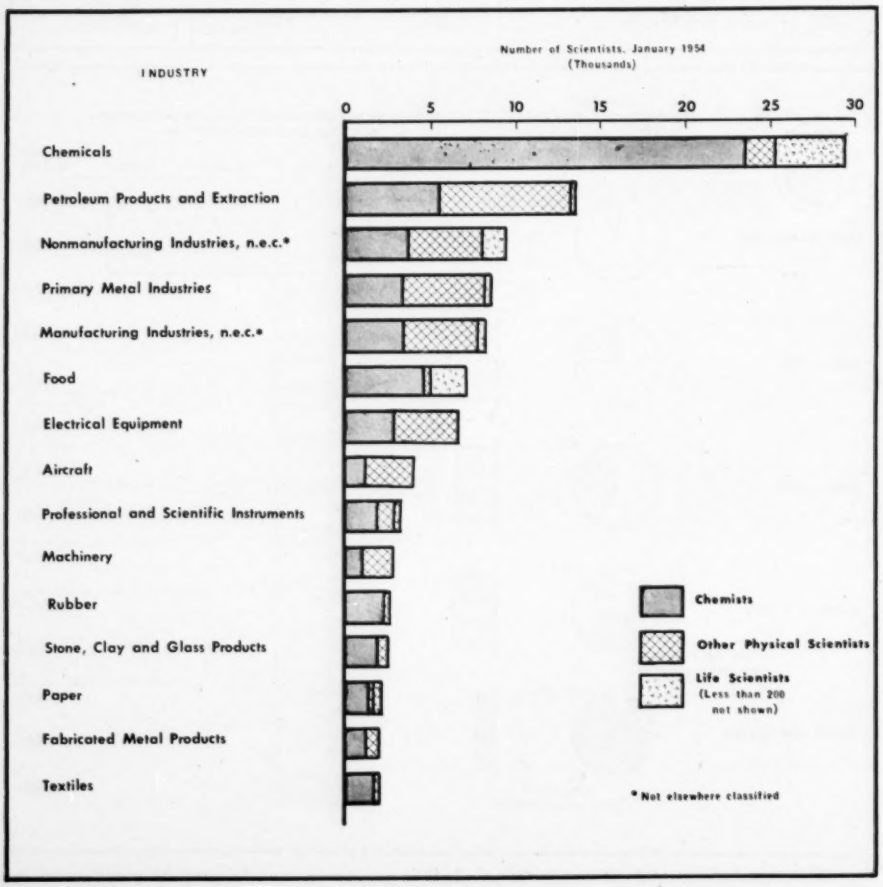


Fig. 4. About 3/5 of the chemists in industry are not in the chemical industry itself.

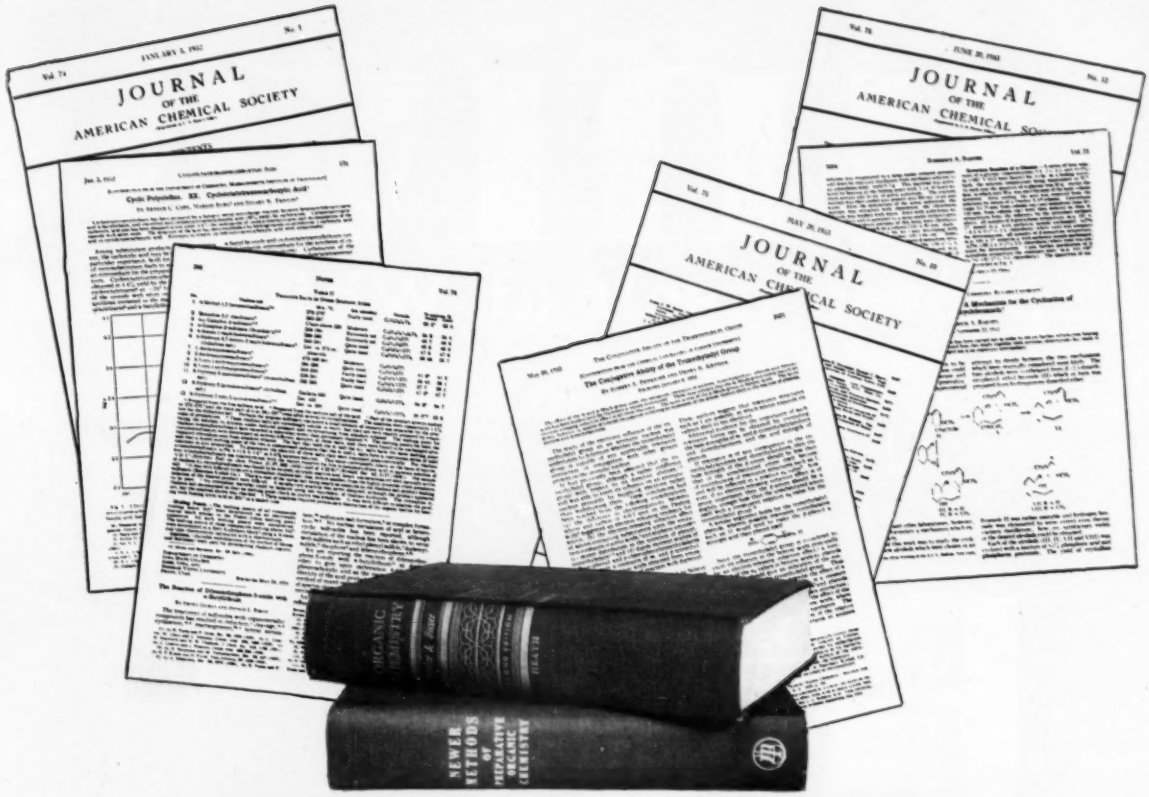
Chemists are likewise employed in a wide range of industries, although, as would be expected, much the largest group shown in Fig. 4. For physicists, the electrical equipment and aircraft industries (about two-fifths of all those in private industry) are in the chemical industry, as were found to be the largest fields of employment, but some were reported to be working in most major branches of manufacturing, in telecommunications, and to a small extent in other nonmanufacturing industries. Mathematicians were working in a still wider range of industries, in both manufacturing and other fields.

The findings in regard to the extensive utilization of physicists and mathematicians in private industry are an index of the tremendous change which has taken place in these professions in recent years. The emergence of physicists from classrooms and university laboratories into the laboratories of business and Government is a development primarily of the past two decades, comparable with the metamorphosis of chemistry during and after World War I. Still more recent is the rapid growth of applied mathematics, partly in connection with programming for the new electronic computers.

The distribution of scientific and engineering employment by size of company is also of interest, from the point of view both of the location of employment opportunities for members of those professions and of the extent to which small business is able to take advantage of scientific and engineering skills. The concentration of scientific and engineering employment in large companies is greater than that of employment in general, though less than that of research costs. In fact, in manufacturing as a whole, the proportion of scientists and engineers in companies with 5000 or more employees was half again as large as the proportion of all employees (about 3/5 and 2/5, respectively).

Less R & D in Small Firms

Small companies utilize relatively more of their scientists and engineers in nonresearch activities than do large companies. The proportion of scientists and engineers engaged in research was approximately 31 percent in companies with 5000 or more employees, compared with 28 percent in those with 1000-4999 employees and slightly under 25 percent in those with less than 1000 employees. This differential is, of course, one of the main reasons for the greater concentration of research cost than of scientific and engineering employment in large companies. But it is not the only reason. According to the survey data, the average cost of R & D per scientist or engineer tends to be higher in large than small companies—owing to an additional complex of factors, such as the nature of product and extent of utilization of supporting personnel. END



OVERLOOKING LITHIUM?

At every new meeting of the A.C.S., research chemists are introduced to more and more papers involving the use of lithium metal, its derivative, lithium hydride, and organolithium compounds in organic reactions. Further evidence of interest in lithium can be found in the presentation of over 700 organolithium papers since 1949.

Examples of lithium organic reactions include lithium metal as a reducing agent in organic reductions using various organic and inorganic solvents. In organic synthesis of the Grignard type, lithium organic compounds, both alkyls and aryls, are used to advantage, particularly where other reagents react sluggishly or in poor yield. They may also be used for the preparation of organometallic compounds of other metals, and as an analytical reagent for nitrogen in rare gases. Lithium hydride is used as a drying agent, as a hydrogen generator, and as a condensing agent. The hydride, particularly, is beginning to receive more interest as research workers learn further about its characteristics.

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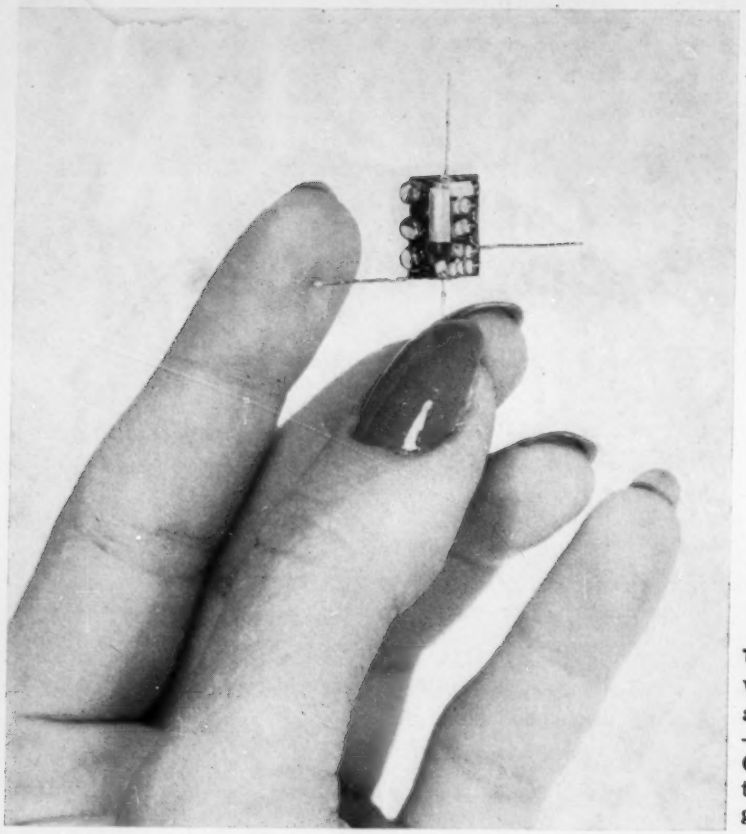
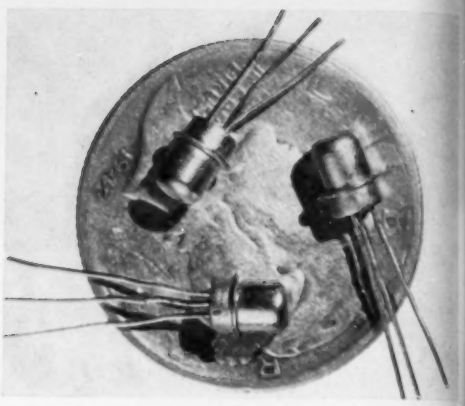
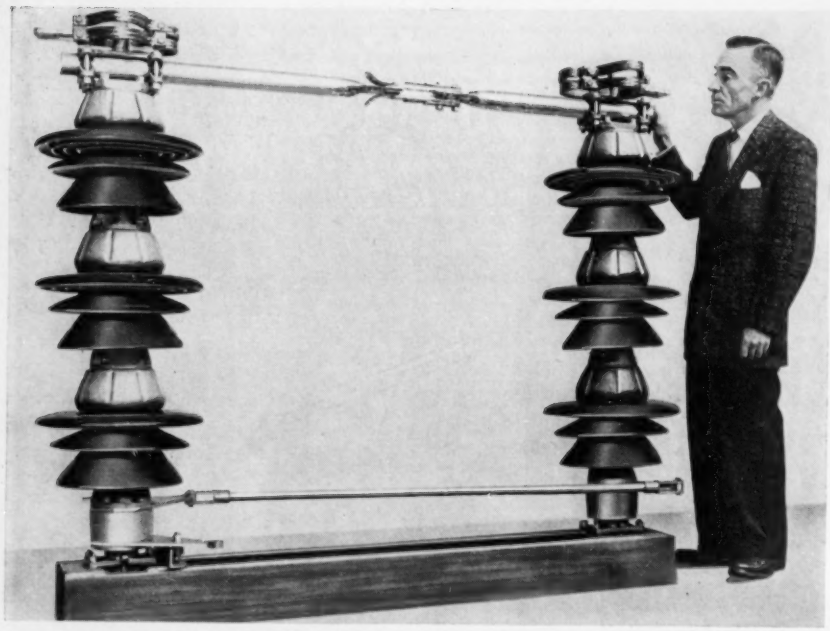




TINY TRANSISTORS SHRINK AMPLIFIER

With a 70 decibel gain, this direct-coupled prototype amplifier—about the size of an ordinary pencil eraser—is one of the smallest electronic circuits known. Constructed with Philco's new tiny M-1 alloy junction transistors, the unit could amplify audio signals in guided missiles, computers or hearing aids.

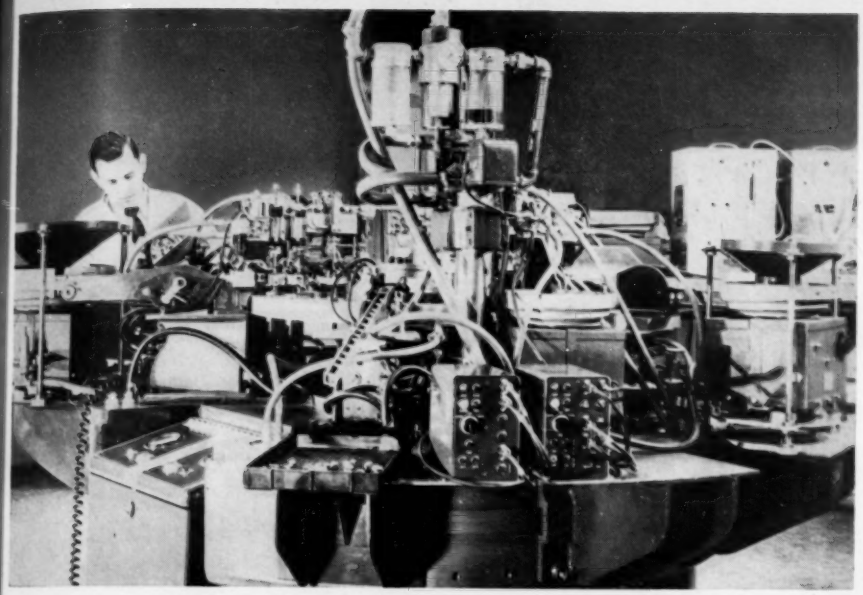


EXPERIMENTAL HIGH VOLTAGE SWITCH BUILT OF ALUMINUM

Aluminum is one of the most versatile of metals and compared with copper, is cheaper and more readily available. From the West Coast comes word of a new use for the metal: an experimental high voltage, single pole switch built on a base of welded aluminum structural sections. Bearing housings, crank levers and inter-tie rods mounted near the base are also of aluminum. Top hardware is provided by aluminum castings and the switch blade is constructed of annealed aluminum tube with flattened ends. According to the Pacific Switchgear Division of Federal Pacific Electric Co., designers and developers of the unit, the object of the experimental project was to develop practical engineering design in view of the cost advantages and availability of aluminum over copper.

LOAD, LIGHT AND LOOK IN 60 SECONDS

Lately we've noticed more than usual interest in faster, more efficient lab products—probably because good technicians are at a premium and every minute counts. Joining the new products parade is Bausch & Lomb with a simple, fast-operating refractometer designated the Abbe 3-L. With the new unit, less than one minute is needed to load, light and look into the instrument to get a refractive index reading of dissolved solids, some opaque solids and liquids. To make inspection even easier, refractometer loading is simplified by mounting the prism assembly in front of the operator within easy reach, and in a horizontal position to reduce spillage.



ASSEMBLES ALMOST ANYTHING

Already used to assemble dry batteries at the rate of about 60,000 a day, this machine can be rapidly tooled up to put together a variety of industrial products. Made by Multra Corp., subsidiary of Barnes Engineering Co., Stamford, Conn., the unit automatically performs all the battery assembly operations that normally require a human operator—feeding, sorting, sizing, forming, orienting and inspecting five different battery parts.

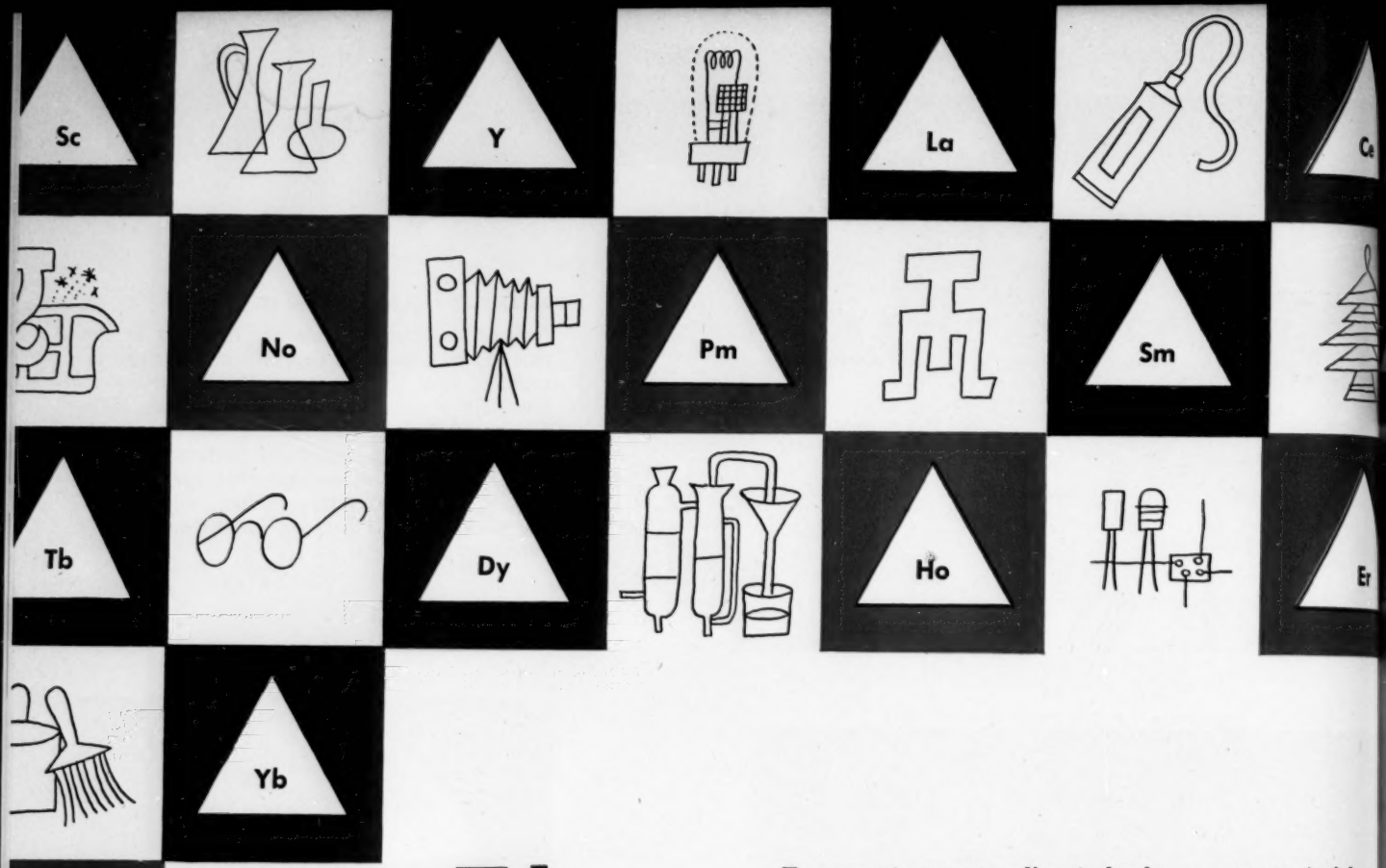
prototypes

PLASTICS REPLACES CABINETMAKER

The chemical industry has brought hi-fi closer to its eventual mass market by developing this foam plastic enclosure for loudspeakers. It would replace comparatively expensive wooden cabinets that require skilled cabinetmakers. Weighing only six pounds including speaker, this 18" sphere is made by Plastilex Products Inc., Philadelphia, Pa.

DIFFRACTION AND SPECTROGRAPHY COMBINED

High speed X-ray diffraction techniques can now be applied to the development of improved materials and the analysis of unknown substances. GE's new XRD-5 X-ray diffraction instrument contains: (1) a high speed proportional counter and preamplifier that frees the technique from dependence on Geiger counters; (2) a single-crystal orienting device for routine identification of unknown organic or inorganic crystals, fibres and wires; (3) helium substituted for air in the path of soft X-rays, extending the sensitivity application range for fluorescent analysis and permitting routine quantitative analysis of elements such as sulphur, chlorine, potassium and calcium; (4) a building block design enabling the addition of components as the need increases and the budget allows.



The Rare Earths

Up from Obscurity

R. C. Vickery

In five years the rare earths will be widely used in metallurgy, chemistry, electronics, nuclear reactors and solar energy devices. Here, Dr. Vickery, one of the few authorities on these elements and their uses, brings you up-to-date on the stepchildren of the Periodic Table.

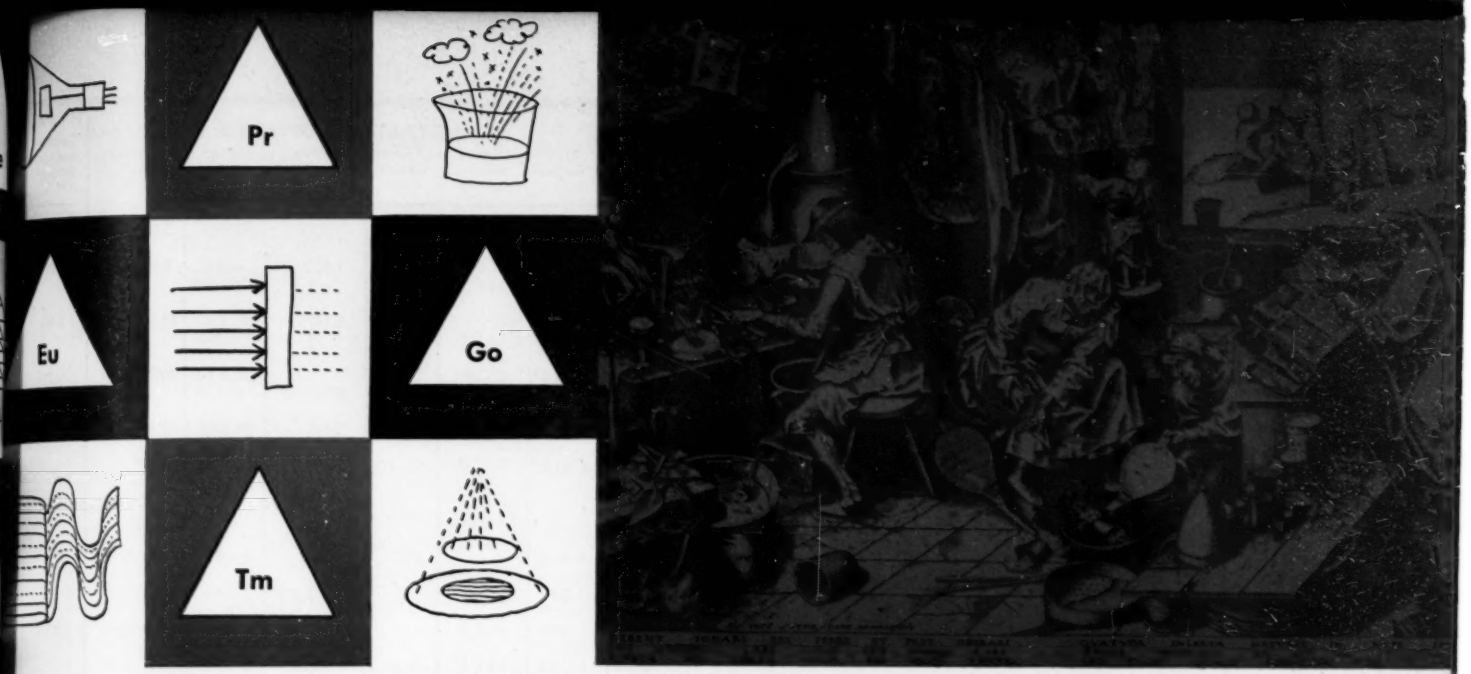
To support our expanding technology, every material—new or old—must be exploited to the limits of its properties. In their pure form, in alloys and in their compounds, the rare earths offer many distinctive characteristics. R&D personnel in all industries must be aware of these little known elements to keep abreast of their respective arts. Here, I hope to fix the rare earths in technological time and space by telling where they came from, their present availability and where they could be playing vital roles in the future.

What Are The "Rare Earths"?

Although our knowledge of rare-earth chemistry has developed immensely over the past decade, the basis for this development was laboriously laid through the years 1750 to 1940 by the stolid endeavors of some 500 scientists of all countries.

Through the century and a half immediately following the isolation of the first rare earth, the essential problems facing the small band of workers in this field were separation and characterization of the elements authentically part of this group. Originally, the term "Rare Earths" was ambiguously used as a generic term for any oxides, metals or their compounds about which little was known or suspected. By integral classification, however, the designation was ultimately restricted to elements of periodic group III A—scandium through lutetium. Subsequent classification upon an electronic structural basis has endowed the elements lanthanum to lutetium with the general title of "lanthanons" or "lanthanides", but the group as a whole—lanthanum plus yttrium plus scandium—are "Rare Earths".

Much of the semi-obscurity in which the Rare Earths languished at first was attributable to the difficulties associated with their separation, either as a group from other elements or individually from one another. It has been truthfully said that, until only very recently, the develop-



Courtesy of the Metropolitan Museum of Art

ment of our knowledge of the rare earths is our knowledge of methods of their separation.

Some 2000 original papers on the rare-earth elements have been published since the discoveries of cerium and yttrium. Of these papers some 1500 have appeared only since 1917, about 30 percent relating to applied fields. Fig. 3 shows graphically the increasing volume of work published and its general field. The significant development, of course, has come from 1947-1948 onward when separational techniques changed dramatically from long and tedius fractional crystallization and precipitation techniques to the relatively rapid and expeditious separations achieved by ion-exchange techniques.

Separation Techniques

Early methods of separation relied almost solely upon what were almost infinitesimal differences in solubility of various rare-earth compounds. The Curies spent four years isolating radium from pitchblende in 20 percent purity by fractional crystallization of the chlorides; by similar techniques, a 20 percent thulium concentrate which had taken six years to collect required a further four years treatment to yield a material of 99 percent purity.

Because of its dual valency (3^+ and 4^+) methods had early been developed for the separation and purification of cerium; the other light lanthanons—praseodymium, neodymium and samarium—merely by virtue of their preponderance, had likewise proved not too difficult to obtain in pure form. Praseodymium and neodymium were the most recalcitrant of this group, but even they succumbed after some six to nine months of recrystallization of their double salts with ammonium nitrate. The purification of yttrium, too, by virtue of its relative abundance, was not too serious a problem, but the elements from europium to lutetium were anathema to those who liked their chemistry administered in doses of clear-cut distinctions. As with thulium, many months and hundreds-of-thousands of recrystallizations were necessary to obtain enough of the rare earths in sufficient purity to warrant a study of their individual properties and characteristics.

Samarium, europium and ytterbium had been found to have, as cerium, dual valences—although with them the valence states were 2^+ and 3^+. By exploiting their tendencies to revert, under certain conditions, to the bivalent state these elements too could be separated and purified with a certain degree of alacrity. Similarly, praseodymium and ytterbium had been shown to have higher (4^+) valence states than their more common tervalency although unfruitful attempts had been made to utilize these variations. Nevertheless, prior to 1939, cerium was the only rare earth whose dual valency had been satisfactorily exploited in separations, preparation and purification of the other earths relying almost solely upon fractional techniques.

By 1946-47, however, valence variation had become the firmly founded basis for separation and purification of not only cerium, but also praseodymium, terbium, samarium, europium and ytterbium. For praseodymium and terbium, however, these processes, although fundamentally of much value, had not been adequately extended and amplified to be of wide separational use.

A By-Product of Hiroshima

With the development of the atomic bomb the problem of rare-earths separation became more general and irritating. Rare earths occur in appreciable quantities in the "ashes" of nuclear reaction, and improved methods for their separation were necessary to permit a fuller and rapid evaluation of their function in the maelstrom of uranium fission.

From the concerted efforts of Manhattan-Project chemists came the development of ion-exchange techniques for separation of the rare earths, as shown in Fig. 1. More mature thought now recognizes the limitations of the tech-

ELEMENT	ATOMIC Wt.	ATOMIC No.	ELECTRON STRUCTURE	IONIC PROPERTIES Ionic Radius	Valence	Electrical Potential	Paramagnetism μ eff	METALLIC PROPERTIES Atom Radius	Crystal Structure	Hardness (Brinell)	Melting Point (in °C)	Density gm/cm³	Boiling Point (in °C)	HYDR Decomposition Temp. (in °C)
Scandium.....	45.10	21	Argon Core $3d_1\ 4s_2$		3		Diamag.	1.439	αF.C.C. βH.C.P.	1.0	1200	α3.2 β3.02	2400	
Yttrium.....	88.92	39	Krypton Core $4d_1\ 5s_2$		3	1.4	Diamag.	1.814 α1.870 β1.872	H.C.P. αH.C.P.		1452	4.34 α6.194	2500	190
Lanthanum ..	138.92	57	Xenon Core $5d_1\ 6s_2$	1.22	3	2.4	0.00	α. 81 1.817	βC.C.P. αH.C.P.	36	810	β6.180 α6.78	4515 ± 150	260
Cerium.....	140.13	58	$4f_1\ 5d_1\ 6s_2$	1.18	3, 4	2.335	2.54	α1.824* β1,821	C.C.P. H.C.P	20-50	815 ± 5	β6.810 6.776	2690 ± 70	
Praseodymium	140.92	59	$4f_2\ 5d_1\ 6s_2$	1.16	3, 4	2.2	3.58		βC.C.P.	25	940	β6.805	3290 ± 90	220
Neodymium...	144.27	60	$4f_3\ 5d_1\ 6s_2$	1.15	3	2.246	3.62	1.818*	H.C.P.	60-70	840	7.004		210
Promethium...	145	61	$4f_4\ 5d_1\ 6s_2$		3				F.C.C. Rhombo Hedral		820 ± 10			220
Samarium.....	150.43	62	$4f_5\ 5s_8\ 5d_1\ 6s_2$	1.13	2, 3	2.2	1.545	1.804		37	1300	7.499		
Europium.....	152.0	63	$4f_6\ 5s_5\ 5p_5\ 6s_2$	1.13	2, 3	2.2	8.3	2.042	C.B.C.		1150 ± 50	5.244		
Gadolimium ..	156.9	64	$4f_7\ 5d_1\ 6s_2$	1.11	3	2.2	7.902	1.794	H.C.P.			7.948		210
Terbium.....	159.2	65	$4f_8\ 5d_1\ 6s_2$	1.09	3, 4	2.2	9.70	1.773	H.C.P.		327	8.332		
Dysprosium ..	162.46	66	$4f_9\ 5d_1\ 6s_2$	1.07	3	2.2	10.6	1.769	H.C.P.		1400-1525	8.562		205
Holmium.....	164.94	67	$4f_{10}\ 5d_1\ 6s_2$	1.05	3	2.1	10.6	1.759	H.C.P.		1400-1525	8.764		
Erbium.....	167.2	68	$4f_{11}\ 5d_1\ 6s_2$	1.04	3	2.1	9.6	1.748	H.C.P.		1400-1500	9.164		200
Thulium.....	169.4	69	$4f_{12}\ 5d_1\ 6s_2$	1.04	3	2.1	7.39	1.742	H.C.P.		1550-1600	9.346		
Ytterbium.....	173.04	70	$4f_{13}\ 5d_1\ 6s_2$	1.00	2, 3	2.1	4.5	1.933	C.C.P		1800 ±	7.010		190-200
Lutetium.....	174.99	71	$4f_{14}\ 5d_1\ 6s_2$	0.99	3	2.1	0.00	1.737	H.C.P.			9.740		

**Trihydroxides ! Monohydroxides * α Pr and α No are distorted somewhat from true H. C. P. △ From Oxide △△ Prepared from Nitrate

Table of properties of the rare earths.

nique, but nevertheless the processes initiated a decade ago produced what was tantamount to a revolution in rare-earth chemistry. In little more than days or weeks, separations could be facilely accomplished which had previously required years of stolid endeavor. Limitations of quantity were imposed, but these could be overcome by multiplication of operations. Thus was initiated the great upsurge of work on the rare earths from 1947 onward. These new separation and purification techniques made available for the first time adequate quantities of rare-earth compounds of purity sufficient to warrant studies on their individual properties.

But why has this development been dependent upon separations? And why has separation been so difficult? Fundamentally, separation has been so difficult, and development of knowledge so long drawn out, because similarity between the rare earth elements is almost isotopic in nature.

Properties

Properties of elements are fundamentally referable to their electronic structure, with major chemical characteristics defined by their outer, or valence, electron shells and their ionic size. These fundamental criteria are shown in the table. With one *d* and two *s* electrons in the outer electron shells, all the rare earths display tervalency as a common basis. From cerium onward, however, these outer valence electron shells are supplemented by a gradual filling of the inner, *4f*, shell. While this gradual enrichment of an inner shell affects those physical properties such as spectra, magnetic properties, etc., and the valence state to which the ions attain, being shielded from outside forces by the external valence shells, these additional electrons have very little effect upon general chemical properties. It is easy, therefore, to visualize the task involved in separating a group of 14 elements, the predominant distinction between each of which lies in one deep-seated electron and a variation of 0.03 Angstrom units in size.

Nevertheless, this problem has now to a large extent been overcome. Sources of rare earths, such as monazite, bastnaesite, gadolinite and xenotime, are now being processed in many ways, but ultimately nearly all production methods are finalized by ion-exchange techniques.

With this increasing availability of rare-earth compounds, growing attention is being paid to their properties and utilization. It is logical that, because of cerium's relative abundance, more should be known about its properties than of its associates. Similarly, less is known of the heavy lanthanons and yttrium and scandium, because of their scarcity. Basically, attention focuses upon the properties and uses of the rare-earth metals. Early methods of preparation customarily involved the electrolytic preparation of their amalgams or alloys with zinc or cadmium, with subsequent removal of the volatile metal by vacuum sublimation. The formation of thermo-stable compounds, e.g., mercurides, rather vitiated this procedure, however, and most recent techniques have produced the metals by electrolysis of fused-salt baths and by reduction of the halide salts by calcium metal. By these techniques all the rare earth metals have been produced in purities greater than 99.9 percent. Attainment of this status has, however, been of such comparatively recent date that much data yet remains to be obtained or disclosed. In general, the table lists the properties determined at this date by scientists.

	OXIDES			NUCLEAR	ABUNDANCE	
Crystal Structure	Melting Point (in °C)	Heat of formation kcal/ mol	Interatomic dist. (in Ang.)	Cross Section (Therm. barns)	% of Group	% of Earth's Crust
Cubic		4.5				
Cubic			2.27	30		
Hexa.	2315	457		80	7	0.00035
Cubic		235		25	31	0.00155
Cubic		417		25	5	0.00025
Hexa.	1900	432.15		220	18	0.00090
Cubic			2.33	4300	7	0.00035
Cubic			2.33	2500	0.2	0.00001
Cubic			2.32	30,000	7	0.00035
Cubic			2.30	1000	1	0.00005
Cubic			2.28	700	7	0.00035
Cubic			2.27	100	1	0.00005
Cubic			2.26	120	6	0.00030
Cubic			2.26	500	1	0.00005
Cubic			2.23	90	7	0.00035
Cubic			2.22	400	1.5	0.00007

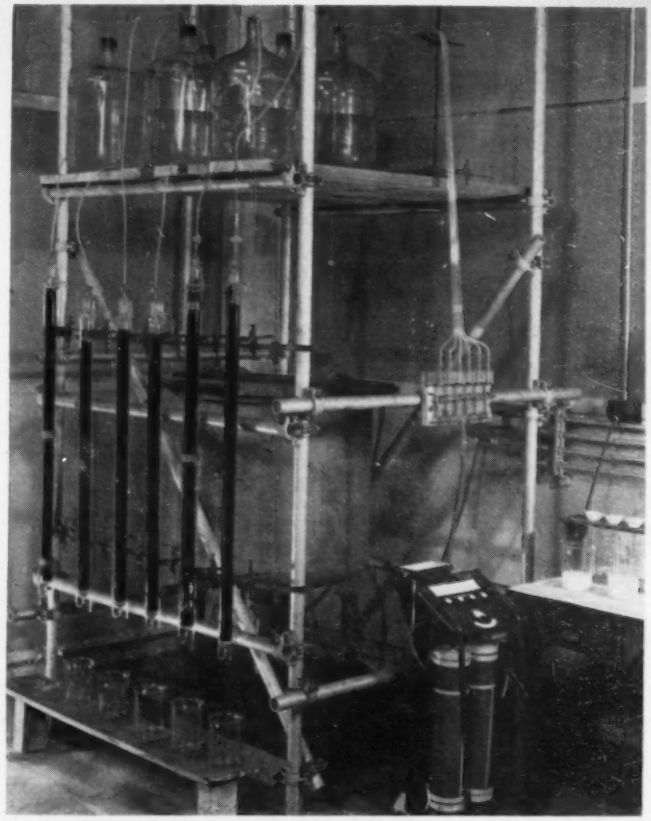


Fig. 1. The ion-exchange method of separating the rare earths is still low in capacity, but improvements are in the offing.

Paramagnetism and Conductivity

The magnetic and electrical properties of the rare-earth metals show interesting features. Paramagnetism, although varying with temperature, is generally strong; cerium retains its paramagnetic properties down through liquid nitrogen temperatures. In spite of their other metallic properties, cerium, praseodymium, neodymium and yttrium are poor conductors of electricity, but recent reports indicate, however, that lanthanum is a super-conductor.

Each of the rare earths forms a basic sesquioxide—R_2O_3—in which the metal ion is tervalent, and generally resistant to oxidation even at elevated temperatures. Cerium, praseodymium and terbium sesquioxide are, however, unstable and higher quadrivalent oxides are the stable forms. Scandium, yttrium, lanthanum and cerium oxides are somewhat amphoteric (capable of reacting either as an acid or a base), the degree diminishing in the order given.

One of the predominant features of rare-earth compounds is the varying colors of their solution. Due to the incompleteness of the inner electron shells, rare-earth ions display band and line absorption of light in the visual spectrum as shown in Fig. 2. While minor variations can be caused by the interference of perturbing electrical fields, either internally or externally produced, the general structure of these spectra remains intact.

Increasing Applications

Properties of the rare earths which have been known for several years have found their application in industry. Early interest in their uses was evinced as a result of the great and rapid growth of the incandescent gas-mantle industry, which led to the accumulation of large stocks of rare earths for which little use was then known. Industrial utilization of these residues received great impetus from their use as flints in cigarette lighters. Although this use is still extensive, it is being rapidly surpassed in importance by the demands of the ceramic industries, by the use of rare earths in phosphors and as alloying additions to ferrous and non-ferrous metals. The general effect of rare earths in ceramic ware is to decrease crazing, to improve luster and to impart various color effects. The dichroic color effect produced by neodymium has not been found to be imparted by any other artificial material. The ultraviolet absorbing powers of rare earths in glasses are well known, e.g., Crooke's sunglasses and welders' goggles; attention is now being paid to the infra-red absorbing powers of such glasses. The use of lanthanum compounds in optical glasses is increasing because it contributes to a high refractive index without increasing dispersion. As well as being employed in glass, the rare earths, particularly ceria, are finding widespread use on glass as polishing agents. By adjusting the temperature at which the rare-earth compounds are ignited to oxides, varying grades of polishing powder can be obtained for use on different types of glasses, i.e., crown, flint and soda.

Improving Metals

In the application of the rare earths to the metallurgical field the chief drawback has been the purity of materials generally available. Alloys of the light rare-earths with other metals are generally quite brittle and easily pulver-

Uses of the Rare Earths

LANTHANUM

METALLURGY: Stainless steel — improves hot work ability; low carbon steel — reduces sulfur content. Magnesium—alloys; with Dysprosium increases Brinell hardness — decreases electrical resistance of magnesium; Zirconium-magnesium alloys.

CERAMICS: Infra-red transparent glass; porcelain glazes dielectric ceramics—titanate base; improvement of SiO_2 glasses for P^h measure; silicate base ceramics—to impart lustre and a blue luminescence in ultra-violet; PbO and GeO glasses—improves transmission of optical glass—gives higher refraction without increasing dispersion; silicate glass gives luminescence in ultra-violet.

ELECTRONICS: Electron tubes—filaments activator—in cathode-ray and infra-red phosphors, acts as porous oxide separator for reserve cathode, cathode emitter; piezo-electrics.

MISCELLANEOUS: Emulsifier — stabilizes oil in water, catalysts magnetic cores, bacteriostatic paints, oxide as gas absorber, activator in MgO and ZnO luminescent materials. Analysis reagent —test for acetate alcoholate test for water, oxysulphide arsenic phosphor; activated by Sm and Cr dehydrogenator and dehydrator of alcohols; serves as acceptors for hydrogen and water, forms hydroxide gel for degradation of nitric or nitrous esters; activators for erythermal fluoride phosphors; ferroelectrics with $A10_3$—GpO_3.

CERIUM

METALLURGY: Cast iron — reduces sulfur content; aluminum coating on steel—produces smoother and more and more ductile aluminum coating on steel; ability—reduces hot shortness and improves ingot surface; steel—increases fluidity — Brinell hardness — resistance to break or bend. Aluminum alloy—increases strength; increases oxidation resistance in Cr-Ni alloys; no spark alloy—for jet brake linings; Cerium-Magnesium alloys; corrosion proofing aluminum.

CERAMICS: Blue luminescent glass; ceramic opacifier, ultra-violet sensitive glass; haze free glass; glass polishing; glazes; prevention of discoloration by X-rays in borosilicate glass; dielectric ceramics; decreases light absorption in glasses in visible range.

ELECTRONICS: Solar energy, cathode-ray tubes with $BaCeO_3$ activated electrodes, glass electrodes for P^h measurement. Vacuum tubes—getter for gases; reserve cathodes, filter for X-rays.

MISCELLANEOUS: Gas mantles — combustion of electrolytic gases; searchlight carbon cores, gives added brilliance; enamels—improves lustre; improves magnesium flash, added brilliance; catalyst—for CO and H_2 combustion — for oxidation in $NaAsO_3$ —H_2O_2 — sulphonation — esterfication processes; abrasive powders, analytical reagent, carrotting. Agent for felt, filter cloth for highly alkaline liquids; lighter flints; porous battery carbons; waterproofing textiles; phosphor activators; photography — photosensitive materials; paint driers; tanning — imparts pliability.

PRASEODYMIUM

CERAMICS: Artificial gems; infra-red absorbing glass; glass coloring.

ELECTRONICS: Capacitors.

MISCELLANEOUS: Low Curie point magnetic materials; medicines catalyst for NH_4 oxidation.

NEODYMIUM

CERAMICS: Artificial gems, infra-red absorbing glass, sunglasses, welders' goggles.

ELECTRONICS: Capacitors.

MISCELLANEOUS: Catalyst for polyester production; fluorescent pigments —for paper and textiles; medicines.

SAMARIUM

CERAMICS: Production of luminescent glass; infra-red absorbing glass.

ELECTRONICS: Neutron absorber—in nuclear reactors.

MISCELLANEOUS: Phosphor activator—infra-red sensitive SrS phosphors —alkaline earth pyrophospors.

EUROPIUM

ELECTRONICS: Radiography — low energy X-ray source; neutron absorber for epithermal and thermal neutrons.

MISCELLANEOUS: Phosphor activator—for high temperature stable alkaline earth silicate phosphors—for Srs infra-red sensitive phosphors—in MgO —ZnO luminescent materials.

GADOLIMIUM

CERAMICS: Glass windows for radiation protection; dielectric ceramics.

ELECTRONICS: Neutron absorber; vacuum tubes—filament coatings.

MISCELLANEOUS: Catalyst for decarboxylation, low temperature attainment activator for La_2O_2S phosphors.

DYSPROSIUM

CERAMICS: High-dielectric insulators.

ELECTRONICS: Thin metal filters for filtering high speed neutrons.

MISCELLANEOUS: Catalyst for decarboxylation and ortho-para hydrogen activator for alkaline pyrophosphors.

HOLMIUM

CERAMICS: Refractories

MISCELLANEOUS: Catalyst for ortho-para hydrogen.

ERBIUM

CERAMICS: Infra-red absorbing glass.

MISCELLANEOUS: Activator in phosphors.

THULIUM

ELECTRONICS: Portable X-rays — low energy X-ray source Tm170.

MISCELLANEOUS: Cancer therapy.

YTTRIUM

CERAMICS: Optical glasses — those without fluorides—gives greater refraction, fluorescent glass; electrically conductive ceramics; insulators.

ELECTRONICS: $BaTiO_3$ semi-conductors; electrodes for inert gas shielded arc welding.

MISCELLANEOUS: Dentifrices — those containing water soluble fluorides; cancer therapy; organic synthesis.

MISCH METAL

Metallurgy: Iron and stainless steel alloys—improves grain structure; deoxidizer in Cr-Ni-Ti steels; austentitic steel, pyrophoric alloy-material which does not give hot sparks and is not easily disintegrated. Coating of steel —improves ductility; improves hot workability in stainless steel; production of nodular grey iron; deoxidizes and degraphitizes cast iron. Mg-Zr-Zn-lanthanon alloy—high temperature and high pressure alloy; Cerium—free rare earths gives corrosion resistant magnesium alloys; improves hot workability of aluminum.

ELECTRONICS: Vacuum tubes—getters; $BaTiO_3$ semi-conductive materials; cathodes—rare earth hexaborides as emitters.

MISCELLANEOUS: Hydrogenation catalyst; lighter flints; textiles — weighting and in the formation of hematoxylin lakes.

YTTERBIUM

Metallurgy: Aluminum alloys.

Ceramics: Dielectric ceramics.

Miscellaneous: Production of cathode ray phosphors.

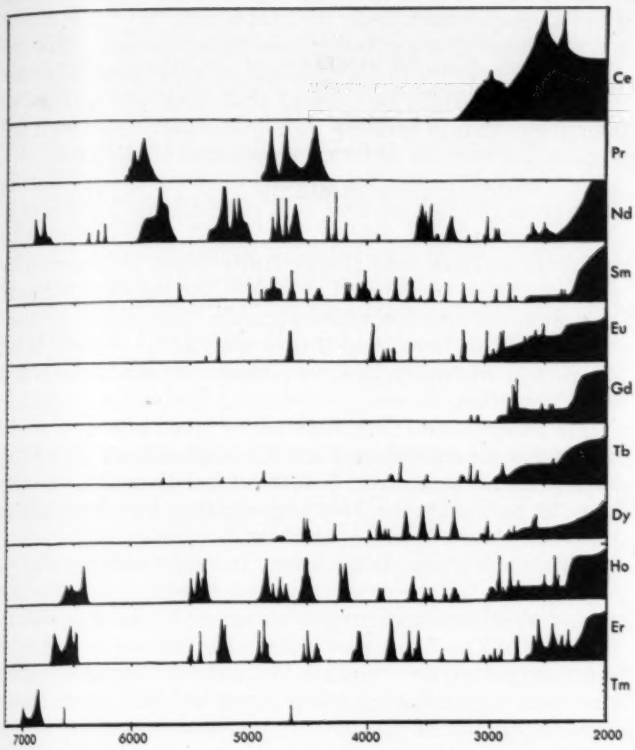


Fig. 2. Lanthanon chloride absorption spectra in the visible spectrum.

ized; a notable exception lies, of course, in misch metal and ferro-cerium. De-graphitizing and de-oxidizing actions have been attributed to cerium when employed in cast iron, and generally small additions of cerium to steel are said to refine the grain, stabilize carbides and nitrides and improve creep and oxidation resistance at high temperatures. Alloys which break down on "hot" working may, with the addition of small amounts of rare earths, be forged or rolled into sheets, rods and tubes.

Non-Ferrous Alloys

Non-ferrous rare-earth alloys which have been studied are chiefly those of aluminum and magnesium. In aluminum alloys the addition of cerium produces higher stress-resistance together with an enhanced resistance to corrosion. Cerium additions to magnesium increase ductility and strength, and induce a feeble magnetism in the alloys. Magnesium-cerium alloys with additions of, for example, zirconium, show many improved properties such as oxidation and creep resistance.

Other Uses

Interest was early displayed in the use of rare-earth metals as catalysts but recent years have seen a falling off of this interest. Fundamental studies have indicated, however, that dysprosium and holmium have extremely valuable catalytic properties, but the scarcity of these rare earths has undoubtedly militated against their immediate application. The brilliance of searchlight arcs is greatly improved by the inclusion of rare-earth fluorides in the carbon electrodes used, and use of the rare earths in alkaline phosphors is of increasing note. Samarium has been used as a flash sensitizer in alkaline-earth phosphors and cerium and europium can be used as main phosphor activators. Other direct rare-earth compound applications now known are in textile waterproofing, scavengers in explosives manufacture, photo-sensitive glasses, glass windows for radiation protection, capacitors for electronic equipment, paint dryers and neutron absorbers in atomic reactors.

Future Applications

There are already indications that certain combinations of rare-earth oxides may prove exceptionally ferromagnetic, that complex rare-earth compounds are piezoelectric, that rare-earth phosphors will shortly be in the forefront of the color television field. As control rods in nuclear piles, gadolimium has been suggested instead of cadmium, but even gadolimium may be replaced by europium. Irradiated thulium finds wide use in portable X-ray sources, while cerium solutions may well prove a dominant factor in the utilization of solar energy.

We have now efficient, if expensive, methods of separation, purification and preparation of rare-earth metals and compounds. By virtue of these we have increasing amounts of pure, but highly-priced compounds to study. We have a certain backlog of fundamental knowledge awaiting application. We also have, by virtue of this existing knowledge, extrapolated possible applications. Essentially, the future lies, therefore, along two lines. Improvement of existing separation techniques with concurrent reduction in cost of production—ion-exchange processes have a high efficiency but low capacity and application of existing and extrapolated data.

Separational techniques are being improved almost daily, but until recently obtaining both high efficiency and high capacity in one process appeared nebulous. Current research has, however, begun to cast a new light upon this field, and the strong probability now exists that this happy consummation will soon be manifest. It is conceivable then that currently known properties can be more fully exploited. Research is, of course, ever continuing on the extent to which known properties can be extrapolated and how such extrapolation can be applied.

Investigations of rare-earth applications have been increasing and accelerating since about 1952. This condition is to be expected: an increase in fundamental knowledge has only developed since about 1947 and application of fundamental data generally lags about five years behind their determination. It is not too much to expect, therefore, that the next five years will show an overwhelming increase in application of rare-earths metals and compounds. END

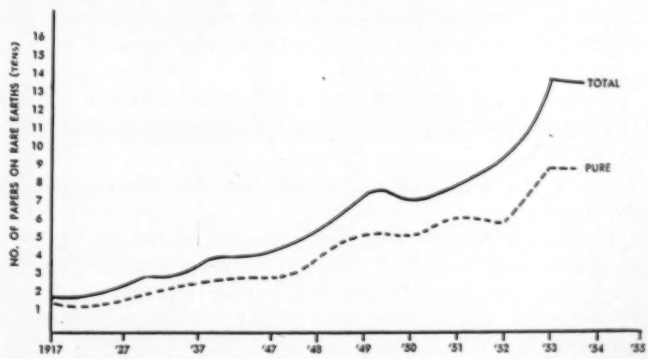


Fig. 3. The increasing number of papers published in the rare earths each year indicates the growing interest in these unusual elements.

How's your O.Q.? Eight key questions applied to your research organization may produce a more productive–and happier–department.

Picture the research executive who has learned to "Make The Most of His Business Day", has surrounded himself with an "Efficient Staff", and has learned all the lessons about "How To Be A Good Boss"—and still can't seem to get the results he wants out of his department. This could be. The best boss and the best staff, all using their time intelligently, can fail to accomplish basic departmental aims if their talents and abilities aren't properly organized.

"Organization" is, however, a nasty word among many technical people. Somehow, it connotes regimentation, clock-punching, red tape, bureaucracy and other artificial restrictions on the free-flowing processes of the mind. Organization is a cold word, the province of soulless efficiency experts and limited little men with stopwatches who try to reduce everything to a colorless norm.

Rightly enough, the good research man sees no place for this kind of nonsense in his order of things, knowing full well that useful discoveries and ingenious solutions come neither from rulebooks nor robots.

Actually, however, there's nothing cold and abstruse about organization. It's just been made to seem that way by some of the people who make a business of keeping it a mystery that is their own special province. After all, any organization is simply a collection of people, and if it attempts to equate out human emotions, ambitions and individualities, it will work no better than no organization at all. The problem of organization is simply a jigsaw puzzle of human relations—but, fortunately, one for which there is usually more than one solution.

The successful head of a major engineering company says, "Organization is not a cold organization chart or a cold manual. It's the welding of a lot of personalities into a smoothly functioning unit. Organizations are men and women, and they're all different individuals. The best plan in the world won't work if the people don't".

Where Do You Start?

The first step in judging the quality of your own organization is to realize what you're looking for—a definable framework within which people can work happily and productively, and in which you can exercise control without losing flexibility.

This is a big mouthful and a big order, but you can get the beginnings of an answer by asking yourself eight leading questions.

1. Have you drawn up an organization chart and/or manual recently?

If you haven't, you probably should, as much for your own sake as for that of the men who work under you. It's only when you start trying to describe jobs and draw lines of authority and responsibility that you discover how indefinite the jobs and how hazy the lines really are. To put down in black and white the responsibilities and authority of each function, clearly and in detail, is the first step in the diagnosis of organizational ills.

Often, the best way to start is to have the men themselves write down their own job descriptions—after you've written down yours. This procedure will not only remind you of things that are being done that you may have forgotten, but it will throw a spotlight on their blind spots and the emphasis, right or wrong, that they are putting on their jobs. And, in inviting widespread participation, it will prepare the way for eventual acceptance of the plan.

It's a natural inclination to start drawing an organization chart from the top, because that's where you sit. There is, however, a lot to be said for starting from the bottom, if you want to know how things really work. When subordinates are asked to whom they report and on what subjects, their answers may be more accurate than those of their supposed supervisors. And if they don't know—which is not too rare a discovery—you've already found a hole that needs plugging.

This analysis and formalization of your set-up is useful even if the organization's basically good already. A written description of objectives, functions and lines of authority helps to pull even the best organization together, and to speed up decisions and operations.

After you've completed your "manual", which may be only a half dozen sheets of typewritten paper, you have only two alternatives—to throw it away, or to keep it strictly up to date. The former of these alternatives is not cited facetiously. Its very creation has already taught everyone concerned something, and has promoted teamwork in the organization.

If it is decided, however, to make the manual into a working tool, it is important that it be kept up to date. For this reason, some companies use the looseleaf form, so that changes can be made quickly and conveniently. An outdated and unrealistic organizational manual soon defeats its own purpose.

2. Is your organizational plan a "natural"?

The wrong kind of organization chart can be a straitjacket—and, in this case, the wrong kind is the unnatural kind. An artificial chart constructed in an ivory tower can, if adhered to rigidly, chop off the flow of information and ideas that are a research department's lifeblood.

To avoid this, the formal organization chart and the "real" organization of the department should not be in

conflict. In every working group there is an informal set of relations that just grows. It is built on personalities of relative forcefulness, and on common recognition of degrees of ability. No formal organization can successfully bypass this variety of survival-of-the-fittest for long. Aside from your job descriptions and employee-expressed recognition of authority, there are lots of clues to the "natural" organization of your operation—the way people group themselves into teams, whom they approach for advice and counsel, and even whom they choose to have lunch with.

When formal organization doesn't match the natural areas of leadership within a department, people just ignore the former. But if the natural leaders are allowed to lead, and the organization built around them, productivity can be substantially enhanced.

3. Are responsibilities made clear and definite?

To quote a leading management consultant, "If the activities assigned to a given position are not clear, duplication may result, confusion and frustration are inevitable, waste follows, and office politics will usually be not far behind".

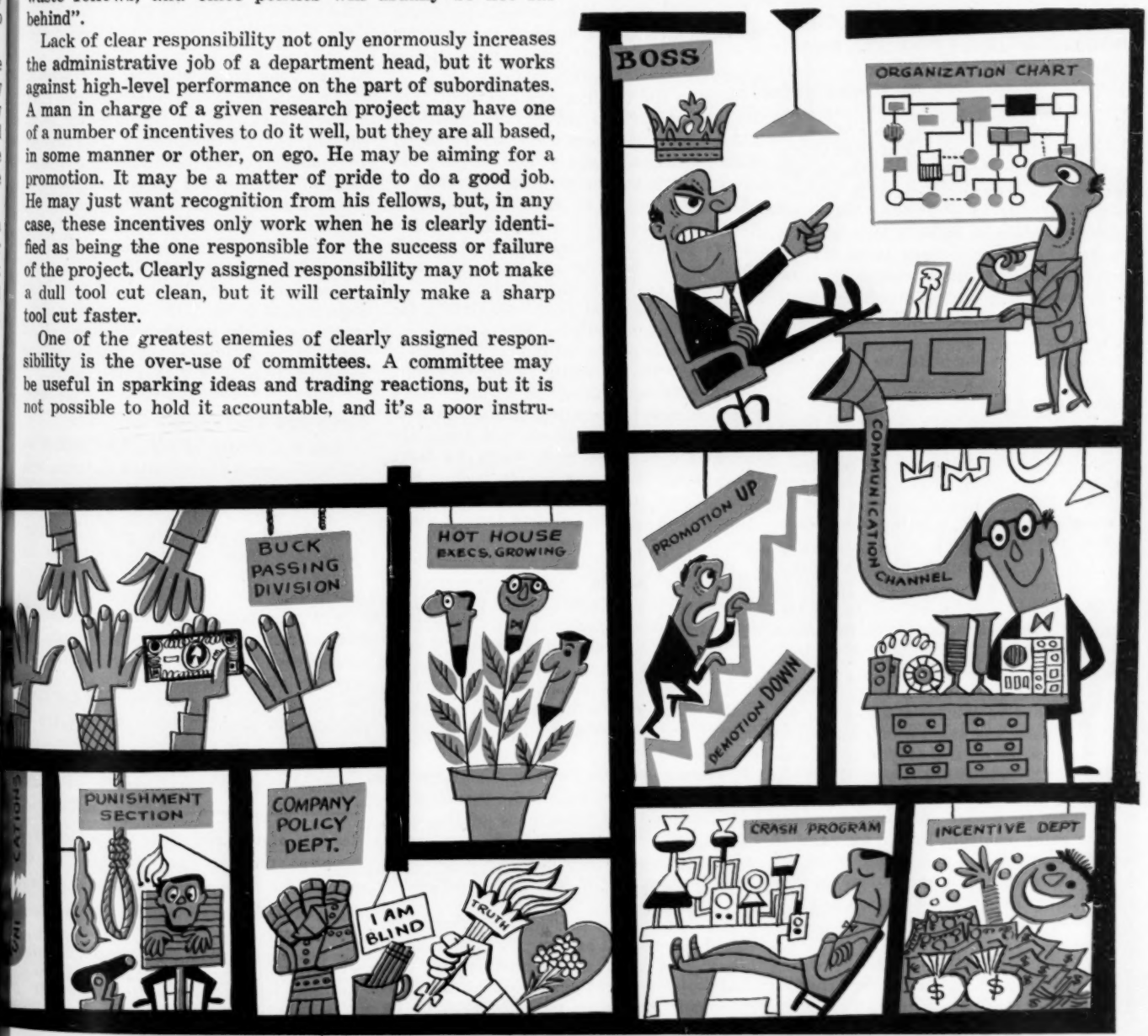
Lack of clear responsibility not only enormously increases the administrative job of a department head, but it works against high-level performance on the part of subordinates. A man in charge of a given research project may have one of a number of incentives to do it well, but they are all based, in some manner or other, on ego. He may be aiming for a promotion. It may be a matter of pride to do a good job. He may just want recognition from his fellows, but, in any case, these incentives only work when he is clearly identified as being the one responsible for the success or failure of the project. Clearly assigned responsibility may not make a dull tool cut clean, but it will certainly make a sharp tool cut faster.

One of the greatest enemies of clearly assigned responsibility is the over-use of committees. A committee may be useful in sparking ideas and trading reactions, but it is not possible to hold it accountable, and it's a poor instru-

How's Your Organizational Quotient?

Luis J. A. Villalon

Management Affairs Editor



ment for decision-making. Too often the committee system is a skirt behind which the responsibility-dodger can hide, and the windy obstacle that frustrates the doer. A ponderous lineup of committees—with too many hours spent in session—is usually a sign more of buck-passing than accomplishment.

4. Do people who have responsibility for results have authority to get them?

Responsibility without authority is the essence of frustration. This is so obvious that it might well be presumed to be a rare condition. It's not.

Here is another spot for some self-examination. Too many executives who have read a book telling them that they must "learn to delegate" are liberal in shuffling out responsibility, but keep the real authority in their own capable hands. They are so used to running things that they just can't bear to trust their subordinates to make any decisions without full consultation. Then they wonder why no one really assumes any responsibility.

It's fair to say that no single other organizational fault is as serious as this one. It bogs the boss down in a morass of details and effectively keeps him from doing any constructive thinking. It slows up all the work of a department, since no project can proceed without a continual series of okays from a single office. It drives away able men who refuse to work unless they're given their head. It almost completely bars the spirit of free scientific inquiry, with researchers being denied both freedom and independence.

An organization dominated by a boss who refuses to delegate any authority soon becomes a haven for the unsure and the ineffective. It not only lacks talent, but lacks the flexibility necessary in a research department that is fulfilling its corporate function.

5. Have you struck a balance between control and flexibility?

In a research organization, where there's a special premium on ingenuity, initiative and individual thinking, as well as the impact of a rapidly changing world, flexibility is a must. But so is some sort of control.

The resolution of this dilemma is not as complicated as it sounds. No heavy-handedness is needed to control a well-organized set-up, because the essence of control lies in the attitudes of the people to be controlled. If the framework is such that they can work happily and effectively, knowing what they're doing and seeing where they're going, control of their activities is almost automatic.

In the research organization, largely staffed by professional adults, too much of the mechanics of formal control is usually a mistake—and the need for it is an admission that something is basically wrong in the set-up. Nothing incites the scientific individual to rebellion against all organization as surely as does excessive red tape. The attempt to formalize research—and to force it into traditional corporate patterns—has cost many a company heavily in results. The same tendency interferes seriously with the recruitment and holding of qualified personnel by the Government.

In routine operations—such as the mass production of a particular serum or precision part—the need for control obviously outweighs that for flexibility. But in research, the opposite is the case.

6. Are communication channels clear?

No organization, no matter how perfectly devised, can hold together without communications—up, down and sideways. The boss must have a simple, clear, informal but definite way of transmitting policy and direction to those responsible for the various projects under way. At the same time, he must be able to keep in at least casual touch with the other employees in his organization. Too often, programs flounder because the director doesn't know how to make himself clear or hasn't the channels through which to do so.

In even the smallest organization, there is an advantage to putting the directions for the more important operations on paper. This is not, as some people suspect, designed to put somebody on the spot if things don't work. It is, rather, an opportunity for the fellow who is getting the orders to ask for clarification or amendment on the basis of a misunderstanding before the project is halfway done.

Equally important is an opportunity for reverse communications. This depends almost entirely on the attitude of one man—the boss. If he listens sympathetically, avoids the temptation of turning every piece of new information into a club with which to belabor someone, and keeps the confidence of those with whom he talks, he'll have a loyal organization feeding him the kind of information he needs. If not, they'll clam up, and he'll find himself working in the dark.

Sidewise communication is principally a matter of morale. A bad organization breeds office politics, and office politics discourages frank interchange of information among equals. If each staff member is conscious of a clearly defined area of operations, destructive rivalries will be eliminated, and they'll talk to one another freely about company problems.

7. Have a program for executive growth?

Such a program would have two facets—(1) training and broadening of the individual within his job, and (2) creating a set of promotion opportunities within the organization. One is, of course, a preamble to the other.

Much scientific personnel is necessarily highly specialized and narrow in viewpoint. Developing such a specialist into a real industrial research man requires a training and broadening process. He must be exposed to the other facets of the business, and be made to understand how his work relates directly to the success or failure of the enterprise—and how the success or failure of the enterprise relates right back to him and his future.

If he has ambitions beyond his particular laboratory, he must have an opportunity to expose himself to management training and to learn that human relations are even more complex than mathematical formulae. Sometimes the company is large enough to run its own development program, but if it isn't, courses in advanced management are available in most major centers.

The second requirement for executive growth within an organization is a planned program for replacing from within the existing group those who leave or retire. Too often, lack of knowledge of his own staff contributes to an executive's overenthusiastic appraisal of an outside applicant. In a good organization, every job has at least one natural understudy—and the understudy knows it.

8. Can your group operate as a team?

In a truly flexible organization, men from different areas can be put together in an efficient team on short notice. This kind of an organization can move fast in an emergency, and outdistance its competition.

The best parallel is the Navy task force. This is a working combination of a group of specialists who work together with the conviction that they all belong to a group bigger than each unit. The acid test of an organization is its ability to organize along such lines when emergencies arise. If it can't, it is rigidities and jealousies and excessive bureaucracy that prevent it.

Here Are The Tools

And this brings us right back where we started—a good organization is, in the end, nothing more than an arrangement which makes it easier for people to work together happily and productively. Effective teamwork is a sign that key executives are strong on human relations and weak on pettiness.

The principles of organization stated in this discussion are merely the tools that can be used to create such a productive and effective atmosphere. Such an environment, by its very nature, must be free and satisfying—and thus, an ideal one for the independent, highly skilled, and intelligent professional personnel that makes up the average research department. END

Reprints of this and other articles on management problems are available to our readers for twenty-five cents each. Write to Research & Engineering, 77 South St., Stamford, Conn. Available articles are:

Time Management for the Research Executive
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Research Administration

MERRITT A. WILLIAMSON

Last month we discussed organization and reorganization. I submitted the thought that reorganization may really be the result of expressing creativity on someone's part who is too far removed from the bench to obtain satisfaction in this area in the normal fashion. In other words, it may be the result of creative manipulation in the only medium available to the administrator—people. The successful reorganization must be accompanied by full realization that relationships among people must be amicably altered. People as people, not as boxes on a chart, must be redirected and reinspired.

One really cannot discuss organization without considering, among other things, the subject of communication, a favorite topic of discussion among managers. As one of the most challenging areas in administration, it could well be the topic for an extended dissertation. This month, we shall discuss several facets of communication. Because of its importance, other phases of the subject will be treated in a future issue.

Kipling's Little Friends

Rudyard Kipling once wrote a little verse which went something like this:

> I have six little friends
> They've taught me all I knew.
> Their names are
> What and Why and When
> And Where and How and Who.

With this as a text, let's take a look at communication. First, you must know what you want to communicate. And second, you must know why it is important to communicate. From management's point of view, policy dissemination gets top priority. I like to think of a policy statement, either written or oral, as being like a seed. If properly stated, and more important, if properly understood, the policy contains within itself all of the cell structure in embryo to be expanded into a full grown plant. All seeds from a particular tree will produce the same kind of tree wherever they are planted and grown. A tree grown from a particular seed would be basically the same tree; it would be identifiable whether it was put into the earth in China or South Africa or whether it was watered from the Ganges or the Amazon.

A policy is like that, too. True, the tree in growing is modified and has its external shape altered depending on whether it grows on a wind-swept plain or under the edge of a cliff. Isn't it much better to transport seeds than to transport and transplant specific trees which may die in transit or at best not fit exactly into the environment in which they are placed? I'm sure you agree with my point.

Some Prerequisites for Effective Communication

Too many times, I think, we do not realize the economy and power in communicating the essence of a policy. Along with this, of course, must go the willingness and ability to delegate responsibility. This, in turn, is based on an inherent trust of human nature and a belief that when people are given all the known pertinent facts, they will arrive at reasonable conclusions most of the time. If you fear the thought processes or distrust the integrity of others, you cannot transmit policy effectively as you will have severe reservations about its judicious application. As a result, you will be perpetually saddled with specific situations on which to rule. To save time, take time to communicate to subordinates the rationale of any policy pronouncement, whether written or oral. The better the objective is understood, the better the policy will serve its purpose. Although this may seem obvious, many managers disregard it and with disastrous consequences.

It seems to me that the manager must communicate policy primarily; secondarily, he must communicate any supporting data and information so that the policy may be put into effect. As managers, we must see to it that the word is passed along. Equally important, we must also insure that the reaction to it is passed back up the line. Paul R. Beall, Advisor to the U. S. Air Force, has written: "Communication is not a stream: it is more like a ping-pong game". The best communciation is two-way communication, up, down and across organizational lines.

Why Communicate?

Why is it necessary to communicate? Ultimately, of course, the goal of communication is to produce action and to further the objectives of the organization. Through delegation of responsibility to intelligent recipients and through transmittal of carefully considered policy, one can save untold time and simultaneously insure uniformity of application except where local conditions require modification. Policy as a statement of what is desired should be a guide, not a strait-jacket!

In talking with research men, one is apt to hear the expression, "Each case must be judged on its own merits". At first glance, this might appear to be contrary to the general policy dissemination advocated above. But as a matter of fact, it is quite in harmony. Provided that policy does exist and has been communicated, then each case is judged at the lowest possible level in conformity with the principles already spelled out and, presumably, understood.

MISSILE SYSTEMS

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What often happens, however, is that policy is nonexistent; hence there is no long-range directive force. Each case must then be elaborately judged on its own merits, and the ruling consideration is how the problem can be settled with least disruption to the status quo, and not how it should be solved in the light of stated objectives. Decisions resulting from cases of this type are certainly not any part of a unified plan and the staff soon gets the impression that management doesn't know where it is going. This may be a false impression, for management may know full well its aims and objectives. But if it is either unwilling or unable to pass policy information down to the level where action may be taken, such unhealthy attitudes are likely to develop.

Deciding When to Communicate

When to communicate is of tremendous importance. Proper timing is of vital significance to effective communication. A statement of action appropriate now might not be appropriate tomorrow morning. Scientists and engineers are used to dealing with "facts" and facts are always incontrovertible, unchangeable, and above all, "true"! The reaction of facts on human beings, however, is conditioned by environment which changes constantly. If you really want to produce an effect rather than pass the word perfunctorily, you must study the timing of each action.

The Receivers of Communication

You must certainly communicate with the person responsible for the action, but this may not be enough. You will, if you are smart, see that the ungarbled word gets to the man who will be taking the action. And you will make sure that he understands it. If you have any past history of communication difficulties in your organization, be sure that what you are trying to say is clear and unambiguous, and that it reaches the right person.

If a man can't or won't communicate to the extent required for concerted intelligent action you are faced with a problem. Perhaps you would like to submit a case about such a problem, suitably disguised, for discussion in this column.

The important matter of *how* to communicate will be discussed in a future column. Some of the criteria involved in determining the how of communication include what topics are appropriate to oral discussion; what should be confirmed in writing; what should be issued as a directive; what should be understood but not written down; what should appear in policy manuals; and what steps should be taken to insure feed-back. Your comments on any or all of these will be welcome.

The relationships between the sender and receiver of communications can hardly be discussed independently of the "how" of communication. Again, because of their scope and importance, these matters will be considered in a separate column.

This month's case bridges the gap between discussions of reorganization and communication. Let's have your ideas and comments on the case that follows.

The Servocomp Company

The Servocomp Company (name is fictitious) manufactures electromechanical devices and employs about 5000 people, of whom about 300 are in the Engineering Department and about 100 in the Research Department. Over the years, the demarcation of functions between the two departments has become less and less clear until at the present time there is not only a complete overlap of functions but even duplication of effort on the same projects. As with many long established companies, the overlap grew so gradually that it never presented a clear-cut problem.

About a year ago, the president of the company decided to reorganize the two departments in order to obtain greater utilization of the scientific and engineering talent available and to eliminate the uncertainties in responsibility.

The heads of the two departments are members of the executive committee of the company and report to the executive vice-president. On making his decision to reorganize early in the year, the president called in the two department heads and instructed them to work out the arrangements together. They were to submit all plans by the end of the fiscal year so that the budget and work programs could be properly evaluated in time for the coming calendar year. The only policy laid down was that the departmental responsibilities were to be in line with their titles, i.e., one was to have the research and development function while the other was to assume only the engineering phase of products coming from R & D in addition to providing engineering service for the customers. If strictly carried out, this move would require that a large proportion of the present Department be transferred to R & D.

The deadline passed with no plan forthcoming. The president had several conferences with the two men. On these occasions there seemed to be general agreement on plans and purposes, but later schisms again appeared between the two men.

Some actual or anticipated by-products of the wrangle are:

- The people in both departments have a rough idea of what is happening and are generally fearful and pessimistic.
- Programs have been hurt by the fact that they were planned under uncertain skies.
- If the reorganization is based on an unhappy compromise, it is possible that the company will acquire a new set-up as ragged as the old.

Forum

What other unpleasant by-products might occur as a result of this problem? What is apt to happen in consequence? What is the source of the difficulty? With whom does

the fault lie? What sound principles of management are violated and what principles and practices could be invoked?

(Please address your replies to Dr. Merritt A. Williamson, % Research & Engineering, 77 South Street, Stamford, Conn. Your name will be withheld on request.)

Discussion of Previous Cases

Comments are still coming in on the Colt and Fenn case presented in the January issue. Frederick P. Napp, Administrative Assistant to the Director, Oak Ridge School of Reactor Technology, stresses the need for supervisors to recognize the individual as such and cites three courses of action:

- Try to get all of the same type individuals in one department
- Mold the workers to the supervisor's pattern
- Use a different approach to each individual as needed.

The first and second courses certainly result in the organization's reflecting the personality and attitudes of the man in charge—a common observation. Following the third course produces an organization which reflects the tolerance, understanding and versatility of the man in charge by virtue of its very complexity. Napp believes that research personnel should be treated differently from other workers and says that they are more rigid in their personalities, ideas and reactions to suggestions than other people. "Therefore, in dealing with research people, we have to allow for their lack of flexibility as well as their lack of understanding of the variables inherent in human beings." This is eloquent support for the often voiced contention that good research men make poor supervisors of other research men. Napp favors Colt as a supervisor for the younger, less experienced workers, and he raises this important question. "Mr. Fenn is willing to consult; does the worker really feel free to do this at any time or does he reach utter frustration before he admits defeat and consults with Mr. Fenn?"

M. E. Volin, Director of the Michigan Bureau of Mineral Research, Michigan College of Mining and Technology, points out that Colt's methods of close supervision probably discourage the men from feeling that they share in the success of the organization. He predicts that a man like Colt will do all the liason work.

Harry G. Vorkink of Consolidated Electrodynamics Corp. takes a stand firmly on the side of Fenn. He says, "there is nothing so destructive to the creative mind as the forced channeling of thought, the clock punching routine, the looking-over-shoulder supervision, and 'that's not the way I told you to do it' idea." He decries the "caste" system where people are "denied the right to think because there is no sheepskin".

An interesting letter from Edward H. Berg of Westfield, N. J., points out that not only is it the supervisor's responsibility to get the job done for the company, but he is also obligated to develop the men he supervises for their own sakes. He advocates periodic project reviews with each individual. He hazards a guess that the reason why men prefer Colt is that they know him better through more frequent contact and perhaps outside of working hours as well, whereas Fenn may be a bit aloof and formal. "The team spirit can give them a sense of belonging to the organization, and can make up for many other faults in a supervisor."

Since these additional comments on the Colt and Fenn case were particularly significant, I thought it worthwhile to continue the discussion this month. This leaves only a little space for comment on the Dr. Abel case presented in February; other observations from readers will follow.

Comments on Dr. Abel case

According to Daniel Hoober of Silver Springs, Md., a number of improper actions contributed to Dr. Abel's dilemma. "Dr. Abel hired Carey as a Senior Engineer for Mr. Brown. This was done apparently without consultation with Mr. Brown and is, I feel, extremely poor policy. If the top men are to work together as a team they must suit each other and not be forced to work together. The 'cold war' between Carey and Brown was caused by the action above and was a continuing factor to the next series of improper actions."

Mr. Hoober goes on to say that "Mr. Brown should not have appointed a project man. This was clearly Carey's responsibility as Senior Engineer. Since Carey was not at the original meeting on requirements, he should have subsequently been briefed and allowed to choose his project man. Even if we accept Brown's appointment of Elson, he should not have been allowed to report to Brown but instead he should have reported to Carey."

At the point where the case ends, a compromise is to be tried. Mr. Hoober feels that it would be wise for Dr. Abel to talk individually with Brown and Carey and then have Brown get together with Carey after pointing out Brown's administrative errors in handling the project. If the differences could not be resolved, "then there is no use trying to keep the two men in the same organization. Dr. Abel would then have the decision as to who would stay".

Mr. Hoober goes on to say that "two personalities successfully weathering a crisis of this type by themselves will be much the better for it, as will the organization".

D. B. Keyes of Arthur D. Little, Inc., points out that it is not Dr. Abel's dilemma but Brown's who is Carey's boss. "If Brown is an experienced executive, he should be able to handle Carey and work effectively with him. One thing Brown might do; and that is to see to it that Carey's salary is the same as his own. I base this idea on the fact that you have indicated that Brown and Carey are equaly competent." END

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R/E views the books

Money and Motivation

BY WILLIAM F. WHYTE

Reviewed by Matthew Radom, Visiting Professor, New York State School of Industrial and Labor Relations, Cornell University

I once asked a successful engineer why he liked his work so much. His reply was, "Everything is so logical. Everything has to prove out. You are dealing with mathematics and physical things and you can always figure out on paper how the end result should look." After I told him that I was in the field of employee relations, he remarked, "I'm sorry for you. I can't figure people out. It must be pretty awful to take their problems all day, every day." In one sense, my engineer friend was right. People are hard to figure out. Their emotions and reactions are often quite opposite to what one might expect. William F. Whyte, a colleague of mine at Cornell, has put together a remarkable documentation about people at work which should help managers and the engineering minded among us to understand that a fact about people doesn't always mean something logical and rational, something that can be figured out mathematically and be proven.

Dr. Whyte is a social scientist. He and his co-workers have trained themselves to see people as they are, not as they should be. When he looked into incentive systems in industry he found, as so many others have found, that the most rational and well thought out incentive plans do not always work. His book explains why. Whyte provides no solutions to solve the riddle of non-acceptance of what appears to be good and sound. He lets the facts of a situation speak for themselves. The way workers feel, act and talk about incentives are the facts, not the computations and logic of the time study engineers who have studied *their* facts very carefully and arrived at just the right work standards.

Whyte's book does not say that money incentives are bad or unworkable. He does point out in study after study that the individual worker by and large cares much more for the esteem of his fellow workers than he does for attaining maximum output and thus maximum earnings. He shows that the middlemen, the largest number of workers in a plant, are constantly caught in a dilemma. In trying to decide whether to make as much money as possible or to keep their individual rates at a point which is socially acceptable to most people in the work group, they are pulled in two directions. For example, here are the words of one middleman, an elderly machinist, who averaged 125% over a two-year period:

"I worked under the same damn system forty years ago and thought when I left that I was done with it. Nobody gets any good from an incentive system. It makes bad feelings among the workers, between the checkers (personnel who apply the incentive) and the workers and bosses. Now you take that . . . over there (nodding toward a rate buster), the incentive system made him what he is. He's got a bad principle and the system brought it out. He'd cut the workingman's throat for a nickel. I've told him to stay away from my machine and not to speak to me because I'd feel insulted. I value my fellow worker's opinion above the dollar. . . . The thing that's so damn aggravating is that one job pays twice as much as it should and the next one only one fourth of what it should. What you make you lose. And when you get one that pays high, the boss comes around and rides your . . . to get it out right away—and you have to kill it. When it runs low, I raise hell with the checker and he takes it to the engineers. They promise to do something about it. Then they say their hands are tied and they can't change it."

The high producers and low producers do not have these emotional reactions to the incentive system. The rate busters turn their backs on their fellow workers and the resisters pay no attention to the system.

I don't wish to leave the reader with the impression that all incentive systems are bad. I believe with Whyte that it is highly important to develop systems which are socially acceptable. If workers were given more opportunity to help create the conditions under which they work, this participation would largely result in their protecting and defending what they have created.

One type of incentive system which seems to produce positive responses from the workers is the Scanlon Plan. In a plant situation where Joe Scanlon represented the workers in meeting with management he suggested a means whereby the management and workers could save the company from going into bankruptcy by working together. The word *participation* looms large in the Scanlon Plan. There are financial incentives, too, but the carrot and stick concept has been abandoned. Instead, everyone from the president down to the janitor thinks in terms of how to keep costs down but not at the expense of putting undue pressure on people or causing fears of job insecurity. Scanlon, now a Professor at M.I.T., is trying to explain his "plan" to young men who someday will enter the ranks of management. Representatives from the "Scanlon Plan companies" meet at M.I.T. every year. I have been told that the exchange of ideas and the enthusiasm of learning from each other how to make the plan work even better produces a setting akin to a revival meeting.

This book should be read by all management people who are thinking of ways to increase productivity through financial incentive systems and by those who have them but don't understand why the workers won't meet the standards which are so logically determined by highly trained engineers. Whyte has added to our meagre sources of knowledge about people at work. As our technology grows and work processes get more complex, social scientists like Whyte will be called on more and more to help us to understand the nature of man at work. *Harper & Brothers, New York, N. Y. 268 pages, $4.00.*

Nuclear Magnetic Resonance

BY E. R. ANDREW

Reviewed by Dr. Frank Herman, Research Physicist, David Sarnoff Research Center, RCA Laboratories

Nuclear magnetic resonance refers to the exchange of energy between an atomic nucleus immersed in a magnetic field and an applied microwave field. The resonance is characterized by a re-orientation of the intrinsic angular momentum or spin of the nucleus relative to the magnetic field direction. Nuclear magnetic resonance experiments can be used to obtain valuable information bearing on the properties of the nucleus, and on the environment in which the nucleus finds itself. Since such experiments can be performed with relatively simple apparatus, even quite modestly equipped laboratories can enter the field. A large number of physical, chemical, metallurgical, geophysical and biological applications already exist.

Three Nobel Prizes in physics have already been awarded to innovators in the field of nuclear magnetic resonance: Rabi for his pioneering work with molecular beams in the late Thirties, and Purcell and Bloch for their first successful experiments using bulk materials shortly after World War II. Because of its wide range of application, its power, and its many profound problems, the subject of nuclear magnetic resonance has attracted the attention of some of the best scientific talent both here and abroad. While the theory and practice of nuclear magnetic resonance is by now well advanced, many challenging problems remain and activity continues at a frantic pace.

This book is concerned primarily with nuclear magnetic resonance experiments in bulk matter, and is the first comprehensive summary of the work carried out in this field to appear in print. After an introduction to the underlying theory, the various experimental methods for detecting the resonance are covered. The remainder of the book is concerned with the measurement of nuclear properties and with the applications of nuclear magnetic resonance in solids, liquids and gases.

The book has many features to recommend it. For example, its very complete bibliography runs to more than 400 entries, most of them bearing post World War II dates. A high level of clarity is maintained throughout. The theoretical and experimental bases of the subject are surveyed with a critical eye.

Unfortunately, Andrew underemphasizes the usefulness of the Bloch viewpoint, concentrating instead on that of Purcell et al. As a result, he is unable to do justice to the spin-echo method (see p. 139).

Because the book does not emphasize the physical processes sufficiently, and because it quotes most of the results and derives very few, it is hardly suitable as a textbook for a graduate physics course, except as a reference work. The articles by Pake (in the American Journal of Physics) remain the best introduction to the subject, together with the original papers by Bloch and Purcell, Bloembergen, and Pound. The forthcoming Pake article in the "Solid-State Physics" series (edited by F. Seitz and D. Turnbull) is eagerly awaited by most workers in the field.

Unquestionably, Andrew's book lives up to the high level of technical authoritativeness characteristic of the Cambridge Monographs on Physics, of which it is the latest addition. Though it cannot be considered the best introduction to the subject, it is a strong contender. Perhaps its greatest merit is the fact that it brings together in one place, and in a critical manner, the numerous results scattered throughout the ever-widening physics literature.

Cambridge University Press (Cambridge Monographs on Physics series). 265 pages, $6.50.

Magnetic Materials in the Electrical Industry

BY P. R. BARDELL

Reviewed by J. W. Cook
Manager, Applied Physics Department
Burroughs Corporation Research Center

The increased interest in magnetic materials due to their use in servomechanisms, amplifiers and computers has made it necessary for engineers to renew their acquaintance with ferromagnetism. At one time, it was very difficult for an engineer to find a textbook which covered the subject of ferromagnetism in sufficient detail and with enough clarity to be of use to him. This is not the situation now.

This book has as its purpose the enlightenment of students of physics and electrical engineering, and practicing physicists and engineers. According to the author, it is intended to "breach the gap between academic study (and) applications". In this respect it falls short of its goal. Perhaps the major criticism which might be leveled at this work is that it lifts the lid of a Pandora's box without adequately dispatching the demons within. It touches upon difficult and complex concepts by brief mention in single paragraphs, where a much more extended treatment is necessary to insure understanding on the part of the reader. It would seem much more profitable to have omitted material of this type which really has little bearing on engineering problems. At the present time, there are many experts in the field of ferromagnetics, but, as is always the case, there are also a large number of pseudo-experts whose talent resides in familiarity with the jargon and a complete repertory of names of prominent persons. It seems that this book may be helpful to the latter group.

Most scientists in physics and electrical engineering are highly interested in the conversion of all literature to the MKS system. Therefore, it seems exceedingly strange that a new book would appear which would devote several pages to conversions between the cgs and MKS systems, and then proceed to use the cgs system with no more apology than that it had been used for many years. This is an unwanted regression.

In general, the book is well written and fairly well organized. Its failure to achieve its stated purpose lies in its ambitious scope and very shallow treatment of the difficult topics. With respect to applications, the equipment discussed is common to Great Britain; little or no attention is paid to work going on outside that region. The tremendous developments in the United States, Germany and Japan certainly warrant much greater treatment than is afforded them in this book. A better title might be *Electrical Industry in Great Britain.*

No reference is made to Bozorth's book on the same subject, which this volume parallels in shallow extent. It would seem that the book offers little that is new and an incomplete resume of what is old. It fulfills no purpose not already covered better in books previously published.

Philosophical Library, New York, N. Y., 288 pages, $10.00.

Reference Texts

Abstracts of the Literature on Semiconducting and Luminescent Materials and Their Applications, 1953 Issue. Compiled by Battelle Memorial Institute. John Wiley & Sons, Inc., New York, N. Y. 169 pages.

Increased knowledge and practical applications have resulted from research in electronic processes in semiconducting and luminescent materials in recent years. To keep the individual in this field informed of the work in more than 50 periodicals, an annual issue of organized material in bibliographic form for desk reference has been compiled.

The Metallurgy of Zirconium, edited by Benjamin Lustman and Frank H. Kerze, Jr. National Nuclear Energy Series, Div. VII, Vol. 4, McGraw-Hill Book Co., New York, N. Y. 776 pages, $10.00.

The text, written by more than 50 contributors, is an outgrowth of the cooperative effort of the AEC and the U. S. Navy to develop marine propulsion through atomic energy. An account of the occurrence, reduction, refining, properties and uses of zirconium and zirconium alloys, it is as complete as the quality of the available data permits.

Proceedings of the RETMA Symposium on Automation. Published by Engineering Publishers, GPO Box 1151, New York 1, N. Y. 114 pages, paper-bound, $5.00.

This is a permanent record of the papers given at the Symposium sponsored by the Engineering Department of the Radio-Electronics-Television Manufacturers Association. Contents of the book are grouped under the headings: Mechanization for High Volume Assembly; Data Sensing, Processing and Utilization; The Future of Automation; Automation for Low Volume Production; and Redesign for Automation of Components and Products.

Tables of Thermal Properties of Gases, National Bureau of Standards Circular 564. 478 pages, $3.75. (Order from Government Printing Office, Washington 25, D. C.)

One of a series of compilations of thermodynamic and transport properties of gases published by the Bureau, this collection of tables covers air, argon, carbon dioxide, carbon monoxide, hydrogen, nitrogen, oxygen and steam. Advances in high-speed flight are particularly dependent on precise knowledge of the behavior of construction materials, the physical and chemical properties of fuels and oxidizers, and the atmosphere.

Letters

Good Neighbor Needs Help

Toledo 1, Ohio

We would greatly appreciate suggestions from any of your readers on the best way to eliminate vapor or condensation which is being discharged from our cyclone collectors in connection with our coffee roasting operations.

In the operation of coffee roasting we liberate a great deal of chaff and dust particles as well as vapor. The dust particles are fairly well collected in our cyclone which is located on the roof of the building and disposed of into a dust collecting box at the bottom of the cyclone. The vapor, however, is discharged into the atmosphere from the top of the cyclone and at times settles down to the street level which is about 100 feet below the top of the cyclone. This vapor is at times a source of complaints to our neighbors and we are, therefore, anxious to eliminate this condition as much as possible. If you know of any method by which this vapor, which we also call condensed steam, could be eliminated or partly reduced we would appreciate very much getting such information.

C. A. ALEXANDER
Plant Engineer
THE WOOLSON SPICE COMPANY
TOLEDO 1, OHIO

Editor's Note: If you have suggestions or information for Mr. Alexander, write to him at above address.

Cavemen with Gadgets

Dear Editor:

After having read several issues of your magazine, I am reminded of what marvellous techniques and tools we have in our hands and what antique habits of thought in our heads. Cavemen with gadgets, that's us. Because our habits of thought and our daily needs have continued to cling to the habits and traditions of a pre-industrial era, we are forced to carry our techniques into the realm of fantasy; space-travel, man-made satellites, not to mention 300hp motor cars, guided missiles and H-bombs. We need a use for our Merlin highjinks, but we don't allow our research to disturb the good old status quo.

This is easily demonstrated. We *have* to have that old stone-age necessity, an enemy, to keep our most over-puffed industry—airplanes—from taking a fall. And how do we maintain an enemy? By using our newest techniques, radio, TV and rotary press, to exaggerate all the differences between the enemy and ourselves. Our technology has grown so much faster than our truly industrial needs that we *have to have an enemy*—at whatever cost—to keep afloat. If our *basic needs* could be appealed to in relation to the hunger of our technology for goods to manufacture, and having no relation to enemies—if we had something besides space-travel and artificial satellites and ingenious gadgets to busy ourselves with—we would not need an enemy on whom most of us at this moment are being propped up.

Don't accuse me of being a "foreign agent" or worse. I say we need an enemy to keep machines running. To this end we need propaganda—and we get it from all sides. But an advocate of research and engineering isn't a subscriber to all the sales manager hands out to the public. A research engineer has to struggle constantly to come into contact with facts. And the greatest fact which the technical professions are not facing today is how much we are relying on our need of an enemy *because* we have clung to most of our pre-industrial tastes and habits, and a pre-industrial set of values.

Because of the entrenchment of finance in land and shelter (the basis of finance until recently) there is a minimum of "progress" in those fields and this acts as an anchor to windward to slow down and even prevent progress in other fields. I am talking now of fundamentals. Take housing. Whatever its change in superficial externals and in its generous supply of marvels, the family dwelling is still something we got from pre-history. Take our cities. In fundamentals they haven't changed in thousands of years. Take the motorcar. There has been no change in today's family car since the enclosure of the old open touring car back in 1917. The car has become a room in the family dwelling—the mobile part of the family's total shelter. Is it designed as such? Has it been adapted to the domestic needs of the tourist? No—because there are those who want to keep the pre-industrial portion of our lives which they most directly control (land and housing) from being powerfully influenced as it would be if the family could dwell day and night on occasion (as on vacation tour or when threatened with atomic annihilation) in their car. What is the consequence of this failure of the family car to grow up to adult status in a country where touring is the favorite pasttime? Concentration on over-powered cars, power window openers, power-seat adjustors, power steering, 300 horses hitched to a vehicle holding two adolescents. And this emphasis on styling! That's where the architect's emphasis is on land improvement—on styling! Is this the kind of food that research engineers can thrive on? It is the road to debility and decay.

This brings me back to the need for a publication such as yours. We have not yet developed the kind of basic thinking that is necessary to keep an economy such as ours growing healthfully—short of war and preparations for war. We should begin to realize that our enemy-need, though very real from an economic point of view, is going to become most awkward if the enemy we have chosen convinces everyone but us that he doesn't need us for an enemy. I would not like to see a magazine like yours get into the field of politics, but you can dig just a bit more deeply into the field of thought than other technical periodicals and many excellent trade journals seem bent on doing.

It is a cinch that the kind of world you are striving toward in your magazine and that research engineers are heading toward in their work is not the one which existed before Watt. Yet that world still is with us today. The small town banker, realtor, lawyer, merchant, politician and homeowner are all toasting their shins in the world of what has been. Their tastes are still adolescent and conspicuously extravagant in a feudal sort of way. Veblen understood them, though he wasn't himself engineer enough to see what the alternative was. We've got to ask ourselves what the hell we're going to use our computers, reactors, automatic controls, feedback and automation *for* if we lose our enemy. Those in positions to see the problem don't want to hear about it—it only makes them mad. They don't want any world except the one they have inherited, plus the improvements they themselves use to *bedeck* the ancient setup. They want to go back into the future our technology is making with their eyes on the old, old ways—ways rooted in the way we subdivide land, build manor houses on it and subordinate the rest of our thinking to *that* good end.

This prevention of sensible growth is turning our entire economy into an infernal machine that will generate more explosive than a dozen H-bombs. Yet this is the road we're treading and no one to say us nay. Is the time coming when even research is to become subversive to preserve what has been?

Forty-five percent of all the research funds spent by this country have been spent in the past five years. Most of this has been predicated on the the assumption that we were faced with an inevitable war. Yet so efficient has this research become that we have turned the weapons of defense into weapons of suicide and there is even some fear that too general testing of nuclear reactive bombs will diffuse enough radiation to affect our genes, though we may not become aware of this until after the damage is done.

What concerns me is not this entrance of degenerative forces into our genes but the failure of those directing our research to prepare us to accept new ways of living that can utilize all these new techniques in the better satisfaction of basic human needs in a world at peace, freed of our present fears. Since we admit that no one can win the next war and since the competition between our enemy promises to be fought on economic, ideological and political grounds rather than with military weapons, it would seem that now is the time to take stock of where, short of war, research and engineering will inevitably take us. The old shell we built up about ourselves in the days of a handicraft and agrarian culture is bound to be burst somehow. Put every Russian on the planet Mars and we would still be faced with this problem. Our technology is so much more revolutionary than Communism that we should begin now to realize that we are much like a nineteenth century boiler into which we are directing 1000-degree steam.

Our thinkers seem obsessed with keeping their eyes on our swift "progress" without pausing to realize that the opposite side of the coin of progress is "obsolescence". You can't have one without the other. But no master study of the problem of obsolescence exists in any language. When the automotive industry sells 8,000,000 new cars in one year, it creates $8 billion worth of obsolescence which the consumer pays for. The real "class struggle" is not between the poor and the rich so much as between those who want the rate of obsolescence swift and those who want it slow. Here is the real battleground and it is high time we realize it.

(Name withheld on request)

Research Reports

Reports in this section may be obtained directly from the Office of Technical Services, U.S. Dept. of Commerce, Washington, D. C., unless another source is stated.

X-Ray Diffraction Data

Section 6 of the ASTM X-Ray Diffraction Data Card File covers approximately 600 new powder patterns and 600 revised and improved data patterns. The File, sponsored by the American Crystallographic Association, the American Society for Testing Materials, the British Institute of Physics and the National Association of Corrosion Engineers, is widely used by research, governmental and industrial laboratories in eighteen countries.

A revised Cumulative, Alphabetical and Grouped Numerical Index of X-Ray Diffraction Data (STP 48E) has also been published.

Section 6 on plain cards (3 x 5 in.), $135.00 for first deck, $50.00 each additional deck. On keysort cards (4 x 6 in.), $185.00 for first deck, $70.00 each additional deck. An index book is furnished with each order, or may be purchased separately for $10.00 per copy.

Orders or inquiries for additional information should be addressed to:

American Society for Testing Materials, X-Ray Dept., 1916 Race Street, Philadelphia 3, Pa.

Plastics Research

Three reports. Research of boron polymers, high-temperature resistant copolymers and method of curing glass-cloth reinforced laminates at room temperature are the subjects of three Air Force studies. The first covers 18 months of research directed toward the synthesis of quadricovalent chelate and quasi-chelate boronic acids and borates.

Research on Boron Polymers, *PB 111892, 85 pages, $2.25.*

In the second study, the reaction between para-dichlorobenzene and alkali metals in the presence of various unsaturated compounds is investigated to determine whether heat resistant copolymers could thus be prepared. Among the unsaturated compounds used are vinyl acetate, ethylene, isobutylene, methyl acrylate, acrylonitrile, and butadiene—1, 3.

Research on the Preparation and Properties of High-Temperature Resistant Copolymers, *PB 111765, 23 pages, $0.75.*

The third study reports that many oxygen-liberating catalysts have been found that will promote cure at room temperature, but care must be exercised in their choice and proportions to avoid too rapid or too slow curing conditions.

Curing of Void-Free Glass-Cloth-Reinforced Laminates at Room Temperature, *PB 111823, 35 pages, $1.00.*

Government Patents Available

Publication of a Supplement describing more than 900 Government-owned patents available for private use on a non-exclusive, royalty-free basis brings the Patent Abstract Series up to date. It lists all patents acquired by the Government from January 1954 through June 1955. Most of the inventions were produced by the defense agencies, Atomic Energy Commission, Federal Power Commission, Tennessee Valley Authority, and other Government branches.

The inventions embrace a wide variety of new products and processes, raw material uses, additional techniques for producing already-known results, advances made in methods and processes.

Patent Abstract Series Supplement, *PB 111854, 134 pages, $3.75.*

Interfacial Phenomena and Nucleation

The proceedings of a conference on interfacial phenomena and nucleation containing papers delivered and relevant discussions are available. Participants in the Air Force and Boston University-sponsored meeting included physical chemists, aeronautical engineers, physicists, metallurgists and meteorologists who shared a common interest in the study of the kinetic aspects of phase transitions. In three volumes.

Vol. I, PB 111893, 225 pages, $5.75.
Vol. II, PB 111894, 182 pages, $4.75.
Vol. III, PB 111895, 116 pages, $3.00.

Navy Develops Active Filter

Design and construction of a small active filter without precision components used in the solution of certain electronic circuit problems is the subject of this report.

The filter has a passband width of 0.01 cycles per second. Its self-tuning range, hold-in range and space requirement cannot be equalled by conventional passive filters, even in banks, with any known mechanism for tuning over the banks. In the frequency-meter application one active filter performs a function that would require one million conventional-type filters, each with an equivalent single-tuned circuit Q of 10 million. In this application, a great simplification in circuitry is obtained by the use of the active filter.

Active filters have been built and operated at 100 kilocycles, 1 megacycle and 10.5 megacycles. In one form, the active filter is capable of extracting a cw signal buried more than 37 decibles below the noise level.

An Active Filter, *PB 111787, 10 pages, $0.50.*

Acid-Resistant Leather

A two-step method for production of experimental leathers resistant to powerful oxidants and reductants used in guided missiles fuel has applications in the manufacture of shoes for wear in industrial plants. The first step in the method calls for chrometanning the leather then treating it by an emulsion method through which 10 to 15 percent of a filler polymer is deposited within the interstices of the hide. In the second step, a resistant polymeric film of about five to six mils thickness is deposited.

Production of Leathers Resistant to Powerful Oxidants and Reductants, *PB 111882, 62 pages, $1.75.*

Visual Training

Uniformly negative results occurred from recent experiments made by the Air Force. Comparison was made between training to read groups of digits exposed tachistoscopically (flashing images into view mechanically at high rates of speed) and training to perceive single digits exposed to the periphery of the retina. Reading speed and accuracy, ability to read a panel of simulated aircraft instrument dials exposed, tachistoscopically, peripheral exposure, and ability to transfer the perception of peripherally exposed objects to symbols other than digits were tested.

The Effect of Selected Visual Training Procedures on the Visual Form Field, *PB 111890, 31 pages, $1.00.*

Alkaline Derusting Process

Effective in the removal of rust from ferous metal parts preparatory to plating or other processing, the alkaline derusting process developed by Rock Island Arsenal may also be used to clean brass or magnesium and strip phosphate coatings and paint. It may be used hot or cold, with or without electric current. Included in this report are the formula, commercial sources of material, and disposal of cyanide wastes safely.

Alkaline Derusting Operations, *PB 111744, 11 pages, $0.50.*

Metal Adhesives Evaluated

Silicone resins, rubbers, copolymers and experimentally compounded mixtures were evaluated following shear strength tests at various temperatures to determine the most suitable type for long-time, high-temperature bonding. It was found that shear strengths averaging over 2000 psi at 70°F, 700 to 900 psi at 300°F and 400 psi at 500°F can be obtained with unmodified resins. Most stress failures, according to this report, result from thermoplasticity of the adhesive at elevated temperatures rather than decomposition.

Investigation and Development of High-Temperature Structural Adhesives, *PB 111768, 128 pages, $3.00.*

Silver Chloride Study

Experiments showing how the photographically important properties of silver chloride vary with the crystal surface find that spherical and flat silver chloride crystals behave differently during etching, development in photographic developers, etching of silver formed by development, chloride reduction to free silver in reducing gases at high temperature, wetting and electrolytic treatment.

Illustrated, the report contains a detailed description of the methods of this investigation and a bibliography.

Anisotropic Photographic and Related Properties of Monocrystalline Silver Chloride, *PB 111897, 33 pages, $1.00.*

Boundary Layer Effects in Aerodynamics

The proceedings of the International Symposium on Boundary Layer Effects in Aerodynamics held at the N.P.L. in 1955 include nine papers on boundary layer research together with the discussions which followed them, plus a survey of present knowledge of boundary layer effects. Subjects discussed include three-dimensional effects, boundary layer stability and transition, viscous effects on swept wings, boundary layer control, supersonic profile drag, shock wave boundary layer interaction and separation effects in transonic aerofoil flow.

Boundary Layer Effects in Aerodynamics, *Department of Scientific & Industrial Research, Charles House, 5-11 Regent Street, London, S.W.1., $5.40*

Synthetic Threads for Shoes

In this study, prompted by the high incidence of failure of shoe threads and cords in military shoes, the effect of storage on the stress-strain properties of stitching thread held under controlled moist tropical and temperate summer storage conditions was evaluated at six-month intervals over a period of two years. Synthetic threads such as nylon and a polyester fiber lost less strength than natural fiber threads. The results of laboratory tests are being checked in field tests.

The Effect of Storage on Shoe Threads, *PB 111976, 31 pages, $1.00*

High–Temperature Alloys

Investigations in the development of forged and cast alloys for high temperature uses were conducted on wrought Fe-base of the D-183 type and both wrought and cast Co-base alloys. A heat treatable, Fe-base, austenitic alloy containing Mn and Cr was modified with B to give excellent stress-rupture results at 1200°F. Designated R-71, this alloy has a 100-hour rupture strength of 67,000 psi at 1200°F. Aluminum additions greatly improved oxidation resistance.

Modifications involving B were investigated in both wrought and cast Co-base alloys.

Development of Wrought and Cast Alloys for High Temperature Applications, *PB 111891, 39 pages, $2.50.*

Chemical Research

Two reports. The first discusses removal of toxic oxides formed by the decomposition of fuming nitric acid. A solution which initially contains equal amounts of NaOH and $KMnO_4$ was found most desirable.

An Evaluation of Methods and Equipment for the Adsorption and Neutralization of Nitrogen Dioxide by Sodium Carbonate, Sodium Dichromate and Potassium Permanganate, *PB 111638, 60 pages, $1.50.*

The second report discusses research into the adsorption of polar molecules on carbon surfaces. The heats of adsorption of ammonia on the graphitized black, Spheron (2700°) are virtually constant at all coverages and approximately equal to the heat of vaporization of ammonia.

Heats of Adsorption of Polar Molecules on Carbon Surfaces, *PB 111708, 31 pages, $0.75.*

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Monsanto Chemical Co., Organic Chemicals Div., 800 No. 12th Blvd., St. Louis 1, Mo.

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speeds determinations of mercaptans in petroleum products, also expedites a variety of other analyses. It generates ions of titrant electrically, right in the sample.
Fisher Scientific Co., 717 Forbes St., Pittsburgh 19, Pa.

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for the measurement and control of the mass rate of flow of liquids in which the rate of heat transfer through the boundary layer of a liquid is utilized to obtain a measurement of flow; is especially suited for corrosive fluids and gases, slurries, hydrocarbons.
Industrial Developments Labs., Inc. 17 Pollock Ave., Jersey City, N. J.

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is especially designed as a power supply for transistorized devices such a portable radio receiver and transmitters. Has 15 photosensitive elements connected in series. The output voltage is approximately 4.0v at maximum power transfer operation, and 8v under open circuit condition.
International Rectifier Corp., Product Information Dept., El Segundo, Calif.

High-Temperature Alloy 36

at 1600°F this alloy has an ultimate tensile strength of 100,000 pounds per square inch and will withstand a constant stress of 28,000psi for over 100 hours. Other uses for the new alloy, besides turbine buckets, may include bolts and fasteners and sheet material for high temperature applications.
Utica Drop Forge & Tool Corp., Utica, N.Y.

Flexible Coaxial 37

section which isolates shock and vibration. Standard contact type of polarized coaxial 3⅛" brass flanges are used. Assemblies are either vinyl dipped or supplied with a synthetic rubber jacket.
Airtron, Inc., Dept. B, 1103 W. Elizabeth Ave., Linden, N.J.

Precision Balls 38

of wrought "SR" steel alloy No. 11A-1132 has high corrosion resistance at both room and elevated temperatures. Has tensile strength of 95,000psi and a yield strength (0.2% offset) of 75,000psi at room temperature, and a tensile strength of 63,000psi at 1200°F.
Industrial Tectonics, Inc., Ann Arbor, Mich.

Long-Life Magnetron 39

designated type 6589 is a non-packaged, high-power, pulsed, tunable oscillator, operating in the 10-centimeter region. It features a "one-piece" anode which assures low losses and long-life performance.
Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L. I., N. Y.

Expanded-Scale Frequency Meter 40

frequencies 1cps to 100kc and providing direct readings accurate within ±2% full scale. A feature of the new instrument is an expanded scale permitting any 10% or 30% segment to be viewed full meter range for high accuracy.
Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.

Frequency Standard 43

produces a crystal controlled spectrum of harmonically-related frequencies. The envelope of the harmonic amplitudes is uniform from 1kc to 85 mc. Useful harmonies are delivered at frequencies of several thousand megacycles.
Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, L. I., N. Y.

Send new product announcements for inclusion in this section to RESEARCH & ENGINEERING, *Editorial Offices, 77 South Street, Stamford, Conn.*

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Radioisotope Catalog

nearly 100 different radioactive preparations are listed together with their respective specifications and price. Special sections of the book are devoted to descriptions of the irradiation facilities in use, procedure for the procurement of isotopes, shipping information, special sources available, service or custom irradiations, neutron-activation analysis, and the Laboratory's waste disposal service for users. *Write direct to*
Oak Ridge National Laboratory, Union Carbide Nuclear Co., Radioisotope Sales Dept., P. O. Box P, Oak Ridge, Tenn.

Conductivity of Solutions 45

controlled by a new electronic instrument for the water treatment, chemical, nuclear energy, power and metal processing industries, where it can be employed in controlling water purity, presence of specific chemicals in solutions, process baths.
Fielden Instrument Div., Robertshaw-Fulton Controls Co., 2920 No. Fourth St., Philadelphia 33, Pa.

Teflon-Coated Glass Yarn 46

is of considerable advantage in the aircraft industry, where aircraft cables have to be pulled through small and sometimes rough openings. It also is used in Navy cable, coaxial cable and as a sewing thread to fabricate items where chemical resistance is desired.
L. O. F. Glass Fibers Co., 1810 Madison Ave., Toledo 1, Ohio

Lucite 47

brochure concerned with the properties of "Lucite" acrylic resin and the applications which are being found for it in the field of lighting. Much of the data it contains is being released for the first time.
E. I. Du Pont De Nemours & Co., Wilmington 98, Del.

Hardened and Ground 48

bars for use as guide rods, shafts, rolls, piston rods, axles, etc. Material is AISI 1060 Steel which has a surface hardness close to 60 on the Rockwell C scale and is precision ground to standard diameters.
Thomson Industries Inc., Manhasset, N. Y.

Power Supplies 49

four new heavy-duty, precision-regulated power supplies are designed for installations that require fixed voltages through 405v, but may be adjusted over the voltage ranges indicated for each model.
Lambda Electronics Corp., 11-11 131 St., College Point 56, N. Y.

Infrared Photo Cell 51

is extremely sensitive in the red and near infrared region of the spectrum. Made with cadmium selenide.
Clairex Corp., 50 W. 26th St., New York 10, N. Y.

Liquid Loads 52

to better absorb and measure coaxial or waveguide power on microwaves as well as lower frequencies.
Chemalloy Electronics Corp., Gillespie Airport, Santee, Calif.

Free Dielectric Materials Kit 53

containing samples of "Fiberfilm", "Tissuglas" and "Amfoil" now available. Data sheets, characteristic curves, price-and-order information also included in permanent file.
Commercial Development Div., American Machine & Foundry Co., 261 Madison Ave., New York 16, N. Y.

Glassed Steel 55

bulletin discusses factors affecting the resistivity of glassed steel and how these factors apply specifically with various acid solutions. Type 53 glass is comparable to laboratory glassware, is fully resistant to all solutions of all acids except hydrofluoric at temperatures up to 212°F. and higher with certain acids. Tests indicate an expected life of 18 to 36 years in continuous operations.
The Pfaudler Co., Rochester, N. Y.

Plastics Catalog 56

and price list on thermoplastic and phenolic sheets, rods, tubes, and films. Miscellaneous resins, cements and supplies are also listed.
Cadillac Plastic and Chemical Co., 15111 2nd Ave., Detroit 3, Mich.

Laminating Tape 57

for laminating transparent sheets of all types of material is particularly recommended for laminating dissimilar metals, or even like metals, where paper or cloth backing would not be desirable.
Permacel Tape Corp. New Brunswick, N. J.

TV Components Package 58

consists of a tuner, i-f strip, sync generator and delay line to help give better reception at a reduced cost in color as well as black and white receivers.
Standard Coil Products Co., Inc., 2085 No. Hawthorne Ave., Melrose Park, Ill.

Subminiature Clutch 59

features a positive-displacement drive that transmits up to 15 inch-ounces of torque at speeds to 1800rpm without external lubrication and at high speeds in an oil bath.
Precision Specialties, 1342 E. 58th St., Kansas City 10, Mo.

Strain Gages 60

of bonded resistance type made of metal foil for use at normal atmospheric temperatures; are available in kits including 20 gages, cement, working tools and instructions.
Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.

Filter Choke 61

designed to provide high reliability through low temperature rise and high insulation safety factors, exceed MIL-T-27 requirements. Four inductance versus current ratings for each unit provide great versatility in application.
United Transformer Co., 150 Varick St., New York 13, N. Y.

Platinum Group Catalysts 62

book has detailed sections on the catalytic oxidation of ammonia; gas purification and measurement of impurities in gases; supported platinum metal catalysts in chemical processing; and supported platinum metal catalysts in petroleum processing.
Baker & Co., Inc., 113 Astor St., Newark 5, N. J.

Counting Rate Meter 63

for use wherever radiation levels must be measured, recorded, or employed in a control system. Converts pulses for analog interpretations of up to 100,000 counts per minute with 2% meter accuracy, less than 2% resolution loss.
Dept. 3336, Berkeley Div., Beckman Instruments, 2200 Wright Ave., Richmond 3, Calif.

Trial Kit 64

containing all required supplies to produce finished photosensitive plates includes 12 4"x5" plates, three test strips, one can each of developer, fixer and image toner, each of which dilutes to one quart, plus processing instructions and a processed sample. The kits are $10.00 each, freight prepaid in the U.S.A.
Metalphoto Corp., 6811 Superior Ave., Cleveland 3, Ohio.

Lab Equipment 65

including centrifuges, circulating systems for circulating tempered water or oil through refractometers, distillation columns and spectrophotometers, and a combination bath or portable circulating device are available with many accessories.
Labline, Inc., 3070 W. Grand Ave., Chicago 22, Ill.

Synthetic Fluids and Lubricants 66

booklet covers properties, applications and characteristics of these polyalkylene-glycol derivatives. They have uses as mechanical lubricants, hydraulic fluids, rubber and textile lubricants, heat-transfer fluids, anti-foam agents, solvents and formulation components.
Carbide & Carbon Chemicals Co., 30 E. 42nd St., New York, N. Y.

Fitting 67

for hydraulic hose assemblies incorporating rubber covered wire braid hose does not require the hose cover to be stripped off. Make-up is accomplished in two simple steps: (1) the hose is rotated into the socket counter-clockwise, and (2) the nipple is screwed clockwise into the hose and socket.
Tube & Hose Fitting Div., Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

Silicon Semiconductor 68

devices including high-frequency bonded diodes and high-voltage and high-current rectifiers. The diodes are useful in 30 to 60mc i-f strips as detectors, clamps, or for clipping. One rectifier rated a 35amp, and others to 600v.
Transitron Electronic Corp., Melrose 76, Mass.

Ceramic Magnets 69

combine adequate energy product with high coercive force, low residual induction, virtually 100% electrical resistivity and exceptional resistance to demagnetization. Also inexpensive.
Electronic Components Div., Stackpole Carbon Co., St. Marys, Pa.

Quick-Disconnect Couplings 70

can be disconnected under pressure without loss of fluid, and operate without impaired flow in either direction.
Eastern Industries, 100 Skiff St., Hamden, 14, Conn.

Permanent Magnet 71

manual summarizes the magnetic characteristics, application and design factors, material characteristics, manufacturing methods and shapes limitations of each material for convenient comparisons.
The Indiana Steel Products Co., Valparaiso, Ind.

Adjustable Radiation Shield 72

for use in making radioactivity measurements on low activity samples, and as a temporary storage area for dangerous isotopes. Made of lead 1-½" thick.
Atomic Center, 489 Fifth Ave., New York, N. Y.

Miniaturization 73

booklet describes the many gains due to miniaturization and illustrates some of them. Certain valuable formulas are presented.
Standard Pressed Steel Co., Jenkintown, Pa.

Printed Circuit 74

copper-clad phenolic laminates possess a bond strength of 12 to 15 lb and a dip-solder temperature resistance of over 30 sec at 500°F. Two foil thicknesses are currently being offered: 0.00135" and 0.0027".
National Vulcanized Fibre Co., Maryland Ave. & Beech St., Wilmington 99, Dela.

Semiconductor Devices 75

including a new device—a silicon double-based diode, a germanium tetrode transistor, a high-frequency silicon triode *ZJ12*, an h-f germanium triode *ZJ13*, a power silicon triode *ZJ16*, and low- and high-current silicon rectifiers, *ZJ16* and *ZJ15* respectively.
General Electric, Electronics Park, Syracuse, N. Y.

Plastics Reagents **99**

list showing compatibility or noncompatibility of 400 reagents to such thermoplastic materials as polyethylene, nonplasticized polyvinyl chloride, high impact polyvinyl chloride, and high-tensile high-temperature polyethylene.
American Agile Corp., Box 168, Bedford, Ohio.

Here's a brief review of last month's advertising in RESEARCH & ENGINEERING as a service to readers.

30,000psi Valve **100**

with finger-tip operation for reactions at all pressures up to and including 30,000psi. Bulletin available.
Autoclave Engineers, Inc., 860 E. 19th St., Erie, Pa.

Permanent Magnet **101**

manual 5-Q-3 discusses physical and magnetic characteristics and applications, includes elector-type chart.
Indiana Steel Products Co., Valparaiso, Ind.

Low-Cost Intermediates **102**

in both anhydrous and aqueous forms are available for shipment in large-volume quantities as well as in smaller containers. Mono-, di-, and trimethylamine.
Commercial Solvents Corp., Industrial Sales Dept., 260 Madison Ave., New York 16, N. Y.

Photographic Enlargements **103**

to over 300,000 diameters are now possible with EMU-3 Electron Microscope. For advanced research.
Radio Corp. of America, Dept. C-281, Camden, N. J.

Consulting Service **104**

in research and technology described in booklet *Problem Solving—The Businessman's Guide to Seeing Alternatives.*
Arthur D. Little, Inc., 30 Memorial Drive, Cambridge 42, Mass.

Rare Earth Chloride **10**

available in large quantities at low cost for a wide varie of industrial uses. It is a water-soluble salt.
Lindsay Chemical Co., 274 Ann St., West Chicago, Ill.

Optical Equipment **10**

listed in Optics Catalog AB. Comparators, magnifiers, m croscopes and accessories. No charge for catalog.
Edmund Scientific Corp., Barrington, N. J.

High-Speed Photography **10**

with high-speed camera. Stops motion for careful study New brochure available.
Wollensak Optical Co., Rochester 21, N.Y.

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resist temperatures of 400°C and over. Consist of one o more fabric bands of resistance wire separated or borderi by high-temperature-resisting fibre yarn.
Standard Scientific Supply Corp., 34 W. Fourth St., Ne York 12, N. Y.

Remote Control **10**

for heavy load. Needs no lubrication, minimizes friction minimizes backlash.
Controlex Corp. of America, Hangar 4, Westchester County Airport, White Plains, N. Y.

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by use of ultra high-speed gas-propelled stream of abrasives for cutting hard, brittle material and removal of surface film.
S. S. White Industrial Div., Dept. 11, 10 East 40th St. New York 16, N. Y.

Meter Torque **11**

held even at low rpm with "Trak" motor control. Developed for controlling toroidal winders.
CGS Laboratories, Inc., 391 Ludlow St., Stamford, Conn.

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